Confined Zone Dispersion Project
Public Design Report

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ABSTRACT

The CZD Process, develop by Bechtel, involves injecting a finely atomized slurry of reactive lime into the flue gas duct work of a coal-fired utility boiler. The principle of the confined zone is to form a wet zone of slurry droplets in the middle of the duct, confined in an envelope of hot gas between the wet zone and the duct walls. The lime slurry reacts with part of the sulfur dioxide in the gas, and the reaction products dry to form solid particles. An electrostatic precipitator downstream from the point of injection captures the reaction products along with the fly ash entrained in the flue gas.

Proof of concept tests that indicated at least 50 percent SO_2 removal was achievable convinced Bechtel that the CZD process was ready for commercial-scale demonstration. The CZD demonstration project was one of the Round 3 Clean Coal Technology proposals chosen by DOE for cofunding, and a cooperative agreement was signed with the Pittsburgh Energy Technology Center.

The project is located at Penelec's Seward Station, about 12 miles northwest of Johnstown, PA. The CZD Process treats about half of the flue gas from the 147 MWe Unit 5.

The CZD Process consists of three major process areas: lime slurry preparation, slurry feed, and slurry injection. Lime slurry is prepared by mixing water and lime hydrate in the preparation area. The prepared lime slurry is pumped to the lime slurry feed area where it is screened to remove foreign material before being sent to an agitated storage tank. A feed pump transfers the slurry from the storage tank to the lime slurry injection area, where the slurry is injected into the flue gas duct using dual fluid atomizing nozzles. Air to these nozzles is supplied by an air compressor.

Installation of the CZD Process at Seward Station required replacing one of the existing flue gas ducts with a new 211-foot-long duct, which includes a 120-foot-long straight section, to provide for the required 2-second contact time between the flue gas and lime. The projected final total cost required to provide the complete and operable CZD system to treat flue gas equivalent to 73.5 MWe is approximately $4,367,000. This figure does not include the cost of some equipment already available at Seward Station. If existing equipment and space were not available, the total project cost would have increased to $5,146,300.

For commercial units, the estimated capital cost varies from $38/kW for a 500 MWe plant to $62/kW for a 150 MWe plant. The estimated 30-year levelized cost for removing SO_2 varies from $220/ton of SO_2 for a 500 MWe plant to $290/ton for a 150 MWe plant.

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LIST OF ABBREVIATIONS

BOD	Biochemical oxygen demand
CCT	Clean coal technology
CEMS	Continuous emissions monitoring system
CFR	Code of Federal Regulations
CL	Calcitic lime
CZD	Confined zone dispersion
CZD-FGD	Confined zone dispersion flue gas desulfurization
DCS	Distributed control system
DOE	Department of Energy
EMP	Environmental Monitoring Plan
EMS	Environmental Monitoring System
EMV	Effective migration velocity
ESP	Electrostatic precipitator
FGD	Flue gas desulfurization
I&C	Instrumentation and control
I.D.	Induced draft
I/O	Input/output
L&N	Leeds & Northrup
MCC	Motor control center
MCS	Management control system
MFP	Multifunction processor
NLL	Normal low level
NPDES	National Pollution Discharge Elimination System
NPT	National Pipe Thread
OIU	Operator interface unit
PaDER	Pennsylvania Department of Enviromental Resources
P&ID	Piping and instrumentation diagram
PCV	Process control view
PDS	Phenoldisulfonic acid
Penelec	Pennsylvania Electric Company
PHDL	Pressure-hydrated dolomitic lime
POC	Proof of concept
PV	Process variable
R-C	Research-Cottrell
RF	Radio frequency
SCA	Specific collection area
SS	Stainless steel

LIST OF ABBREVIATIONS (Cont'd)

TSS	Total suspended solids
UPS	Uninterruptible power supply
VSD	Variable-speed drive

LIST OF UNITS

A	Amperes
acf	Actual cubic feet
acfm	Actual cubic feet per minute
bhp	Brake horsepower
Btu	British thermal unit
Btu/lb	British thermal unit per pound
cfm	Cubic feet per minute
dia.	Diameter
ft	Feet
gpm	Gallons per minute
gr	Grains
hp	Horsepower
Hz	Hertz
kW	Kilowatt
kWh	Kilowatt-hour
lb	Pounds
mA	Milliamperes
mgd	Million gallons per day
MV	Megavolts
MW	Megawatts
psi	Pounds per square inch
psig	Pounds per square inch gauge
scfm	Standard cubic feet per minute
tph	Tons per hour
V	Volts
Wh	Watt-hours

Executive Summary

EXECUTIVE SUMMARY

BACKGROUND

The CZD process, developed by Bechtel, involves injecting a finely atomized slurry of reactive lime into the flue gas duct work of a coal-fired utility boiler. The principle of the confined zone is to form a wet zone of slurry droplets in the middle of the duct confined in an envelope of hot gas between the wet zone and the duct walls. The lime slurry reacts with part of the sulfur dioxide (SO_2) in the gas, and the reaction products dry to form solid particles. An electrostatic precipitator (ESP) downstream from the point of injection captures the reaction products, along with the fly ash entrained in the flue gas.

In 1986, Bechtel's CZD process was selected by DOE for proof-of-concept (POC) testing on a 5 MW scale at Consumers Power Company's 260 MW J.H. Campbell Station Unit 1. Test results showed that SO_2 removal in excess of 50 percent was achieved. In addition, the process did not cause any corrosion in the flue gas duct downstream of the injection point or in the electrostatic precipitator (ESP).

Following these tests, large-scale POC tests were performed at Penelec's (PENnsylvania ELEctric Company) Seward Generating Station (Seward Station) Unit 5 (147 MW), where the CZD system was retrofitted to one of two parallel flue gas ducts. The results of the large-scale POC tests confirmed that a true confined zone could be obtained and that duct deposits could be prevented by limiting injection rates. However, the short distance between the injection point and the duct turning vanes limited the quantity of lime slurry that could be injected into the duct and consequently limited the percent of SO_2 removal.

The results of both POC tests convinced Bechtel that the CZD process was ready for commercial demonstration in a duct of proper length. Bechtel therefore proposed to the U. S. Department of Energy (DOE) that one of the two flue gas ducts leading from Penelec's Seward Station Unit 5 be retrofitted for a demonstration project. The installation of the CZD process would require replacement of the B duct (the west duct) with a 211-foot-long duct, including a 120-foot-long straight section to permit the addition of atomizers and provide adequate lime slurry injection rates with sufficient residence time.

In 1989, during Round 3 of the Clean Coal Technology Program, DOE accepted Bechtel's proposal for the 37-month CZD demonstration project, to be carried out under a cooperative agreement with the DOE's Pittsburgh Energy Technology Center – with Bechtel as the major participant. The primary objective of the cooperative agreement is to conduct a cost-shared project that will demonstrate, on a commercial scale, Bechtel's CZD flue gas desulfurization (CZD-FGD) technology.

The parties to the cooperative agreement envision that successful demonstration of the CZD process will allow coal-burning plants to comply with Clean Air Standards at a minimum cost. Without an economical solution to the removal of SO_2 from the discharged stack gas, most of the smaller and older plants would have to cease operations because of noncompliance with 1995 environmental laws. CZD, with its low capital cost, low operating cost, and relatively minor space requirements will be a feasible option for installation on older generating stations, significantly affecting the inhabitants of surrounding areas, who depend on the stations for economic survival.

LOCATION

Penelec's Seward Station, where the CZD Project will be demonstrated, is located in western Pennsylvania, approximately 12 miles northwest of Johnstown on the southern bank of the Conemaugh River in East Wheatfield Township, Indiana County.

CZD TECHNOLOGY AND OPERATION

Bechtel patented the CZD process in 1986. It is the only duct injection technology that employs the confined zone concept. The mechanism of the process for removal of SO_2 is well understood. In the presence of water, SO_2 from the flue gas is absorbed as sulfurous acid, which, when exposed to lime, reacts to produce calcium and/or magnesium sulfites and sulfates, which are subsequently removed by the downstream particulate removal equipment. When dolomitic lime is used, some NO_x removal may occur because of the presence of the magnesium hydroxide in the dolomitic lime. This magnesium hydroxide reacts with sulfurous acid to produce magnesium sulfite, which favors the removal of NO_x. The precise chemical mechanism for NO_x removal is not well understood at this time.

In the CZD process, the wet reaction particles and unreacted lime must dry before contacting the duct turning vanes, particulate removal equipment, etc., or they will adhere to these surfaces and cause unwanted deposit buildups which could plug the duct and thus affect operations. To prevent this from occurring, the prepared lime slurry is injected close to the center of the flue gas duct, parallel to the flow of gas. The use of narrow-angle sprays and carefully positioned atomizers makes it possible to obtain a wet zone in the middle of the duct for SO_2 removal while maintaining an envelope of hot gas between the wet zone and the duct wall. This is the principle of the confined zone. As the cone of spray moves downstream and expands, the gas within the cone cools and the reacted lime slurry on the outside of the cone mixes with the hot gas and dries rapidly. If the proper slurry concentration and injection rate are employed, drying is complete before the droplets contact the walls of the duct. Approximately 90 to 95 feet downstream of the injection point, the free moisture in the spray completely evaporates, and the dry solid contacts the duct and the turning vanes without adhering to them. The dry reaction particles and the unreacted lime are then removed by the ESP, along with the fly ash.

THE PROCESS FLOW

Basically, the CZD process consists of the preparation of lime slurry by mixing water and lime hydrate in the lime preparation area. The existing lime silo at Seward Station has about 1 day of gross storage capacity for hydrate, which is adequate for the operation of the CZD system with daily lime deliveries. The prepared lime slurry will be pumped to the lime slurry feed area where it will be screened to remove foreign material before it is put in storage tanks. The storage tanks will be kept in constant agitation to prevent the lime from settling. Feed pumps then will pump the lime to the lime slurry injection area. The lime will be injected into the duct using dual fluid atomizing nozzles. One 2,000 standard cubic-foot-per-minute (scfm) oil-free, screw-type air compressor will supply compressed air for the CZD system. A spare compressor will be provided so that up to 4,000 scfm of compressed air will be available, if needed.

The lime injection rate will be controlled by the outlet flue gas temperature setpoint at the end of the straight duct section. Automatic control will be accomplished by cascading the lime slurry flow controller and/or the lime slurry injection pressure controller. This arrangement prevents overcooling the flue gas by excessive injection in case of reduced boiler load and avoids an inadequate injection of lime slurry in case of increased boiler load.

THE DESIGN AND ENGINEERING EFFORT

Because this project was conducted on a fast-track basis, design of the duct modifications required to install the CZD system was started in June 1990, 4 months before the cooperative agreement was executed by DOE. Bechtel established the fast-track schedule in order to meet Penelec's pre-scheduled, annual, plant outage.

Construction began in March 1991 and was completed 45 working days later, before Penelec's planned outage date. During the outage, the existing duct was removed and the new, 211-ft-long duct was connected.

A second period of design and construction is scheduled from December 1991 to May 1992 when modifications will be made to fully integrate the CZD system with the boiler operation, enabling operations to be conducted on a continuous basis. Bechtel will complete additional design, procurement, installation, and facility construction, as necessary, to permit a 12-month continuous demonstration. The CZD system will be fully instrumented and integrated with the operation of Penelec's Boiler 15. The goal will be to demonstrate the performance of the CZD process for SO_2 removal without affecting either boiler operation or particulate emissions.

PROJECT CAPITAL AND OPERATING COSTS

The projected final total cost required to provide a complete and operable CZD system to treat one-half of the flue gas from Boiler 15 (73.5 MW) at Seward Station is approximately $4,367,000. This figure includes all proprietary or "business-sensitive" equipment such as atomizer lances, nozzles, and associated headers, piping, instrumentation, and other parts of the slurry injection atomizer array system.

Since earlier CZD proof-of-concept work was done at Seward Station, it is not necessary to purchase and install certain items of equipment such as the lime slurry feed and storage tanks, the grits tanks, the vibrating screen, and the water booster pump. Seward Station also has an existing lime silo and lime preparation sump, as well as space in its existing buildings for installation of air compressors and a receiver. If this existing equipment and space were not available, the Seward Station CZD installation would cost an additional $778,900 for a total project cost of $5,146,300.

It is expected that there will be some cost improvement in future plants based on design maturity and plant operating experience, because the Seward Station CZD system is the first commercial installation. While most of the CZD equipment is standard off-the-shelf design, the atomizer nozzles are expensive, special prototypes. As the market for CZD installations develops and production quantities of nozzles are required, the nozzle cost will decrease.

Preliminary estimates indicate that the projected total capital cost for plants in the range of 150 MW to 500 MW varies from about $38/kW (500 MW) to $62/kW (150 MW). The capital costs rise sharply below 150 MW.

The projected annual operating costs vary from $310 per ton of SO_2 removed from a 50 MW unit, to $165 per ton of SO_2 removed from a 500 MW unit. Similarly, the projected 30-year levelized costs vary from $466 per ton of SO_2 removed from a 50 MW unit, to $220 per ton of SO_2 removed from a 500 MW unit.

1.0

Introduction

1.0 INTRODUCTION

1.1 SIGNIFICANCE OF CZD

The CZD (Confined Zone Dispersion) Project at the Penelec (PENnsylvania ELEctric Company) Seward Station is the first full-scale demonstration of Bechtel's CZD technology for reducing sulfur emissions. When implemented, the CZD process will allow coal-burning plants to comply with the Clean Air Standards at a minimum of cost. Because of its low capital cost, low operating cost, and relatively minor space requirements, CZD is a feasible option for installation on older generating stations.

CZD will significantly affect the economy of the surrounding area, which depends on these stations for their economic survival. For example, without an economical solution for the removal of sulfur dioxide (SO_2) from the discharged stack gas, most of the smaller and older plants would have to cease operations because of noncompliance with 1995 environmental laws.

1.2 PURPOSE OF THE DESIGN REPORT

The purpose of this Public Design Report is to consolidate into a single document for public use available nonproprietary design information on the CZD Project. This report also contains background information, an overview of the project, and pertinent cost data. The report supplements and clarifies other reports and information concerning the project.

This report is limited to nonproprietary information, and is intended to serve as a reference for the design considerations involved in a CZD installation.

1.3 HISTORY OF THE PROJECT

The CZD process involves injecting a finely atomized slurry of reactive lime into the flue gas duct work of a coal-fired utility boiler. The principle of the confined zone is to form a wet zone of slurry droplets in the middle of the duct confined in an envelope of hot gas between the wet zone and the duct walls. The lime slurry reacts with part of the SO_2 in the gas, and the reaction products dry to form solid particles. An electrostatic precipitator (ESP) downstream from the point of injection captures the reaction products, along with the fly ash entrained in the flue gas.

In 1986, Bechtel's CZD process was selected by DOE for proof-of-concept (POC) testing at a 5 MW scale. These initial tests were performed using a slipstream of flue gas from Consumers Power Company's 260 MW J.H. Campbell Station Unit 1. Test results showed that SO_2 removal in excess of 50 percent was achieved. In addition, the process did not cause any corrosion in the flue gas duct downstream of the injection point or in the ESP.

Following these tests, large-scale POC tests were performed at Penelec's Seward Station Unit 5 (147 MW), where the CZD system was retrofitted to one of two parallel flue gas ducts. The results of the large-scale POC tests confirmed that a true confined zone could be obtained and that duct deposits could be prevented by limiting injection rates. The short distance between the injection point and the duct turning vanes limited the quantity of lime slurry that could be injected into the duct and consequently limited the percent of SO_2 removal. The results of both POC tests convinced Bechtel that the CZD process was ready for commercial demonstration in a duct of proper length. Bechtel's proposal, in 1989, for a CZD demonstration project was accepted by DOE during Round 3 of the Clean Coal Technology Program.

The purpose of the proposed CZD Project was to demonstrate CZD technology over an 18-month period. It was proposed that one of the two flue gas ducts leading from Seward Station Unit 5 be retrofitted for the CZD Project. The installation of the CZD process requires the replacement of the B duct (which is the west duct) with a 211-foot-long duct. This includes a 120-foot-long straight section, to permit the addition of atomizers and provide adequate lime slurry injection rates with sufficient residence time.

1.4 TECHNICAL OBJECTIVES OF THE DEMONSTRATION PROJECT

The CZD process involves the injection of finely atomized sprays of lime slurry into the flue gas duct ahead of solids collection. This project will use a variable test program to evaluate different types of atomizers and the injection of different types of absorbents (dolomitic, calcitic, etc.) using low-sulfur coals to determine the effects on SO_2 removal and on the capability of ESP control of particulate emission and percent opacity. This demonstration will be carried out at Pennsylvania Electric Company's Seward Station in Seward, Pennsylvania, on the 147 MW Unit 5 in a modified duct between the first and second ESP. The process produces a nontoxic solid waste. After the variable-test program, a long-term, continuous, fully automated and integrated test (with the regular power plant operation) will be performed. The specific objectives of this project are to:

- Demonstrate the applicability of the CZD-FGD process for use in utility boiler flue gas operations which are derived from low- and high-sulfur coal combustion.
- Evaluate/quantify the CZD-FGD process variable effects and determine the optimum operating requirements for long-term continuous testing.
- Determine the operability and reliability of CZD-FGD during long-term testing and its impact on downstream operations, e.g., ESP and emissions (particulate, opacity, etc.).
- Demonstrate reduction of utility boiler flue gas SO_2 emissions by 40 to 50 percent.
- Verify that the CZD-FGD process has no detrimental impact on waste streams.
- Determine the cost of CZD-FGD, with the aim of achieving SO_2 removal costs (capital and operating) in the range of $300/ton or less.
- Document this CZD-FGD test effort sufficiently to inform the public about the capability of the process and its applicability to the U.S. utility industry.

1.5 ORGANIZATION OF THE CZD-FGD PROJECT

The CZD-FGD project is a cooperative agreement between interested parties. The CZD-FGD project organization and participants are shown in Figure 1-1. The relationship between participants is shown in Figure 1-2. The main contractor, Penelec (the host site's owner), and the four construction subcontractors are shown in Figure 1-3, along with their areas of responsibilities.

1.6 DOE ROLE IN THE PROJECT

This project is being carried out under a cooperative agreement with the U.S. Department of Energy (DOE), Pittsburgh Energy Technology Center, and Bechtel as the major participant.

1.6.1 Cooperative Agreement

The primary objective of this cooperative agreement is to conduct a cost-shared project that will demonstrate Bechtel's CZD flue gas desulfurization (CZD-FGD) technology. The parties envision that, if the demonstration project is successful, Bechtel CZD-FGD technology could become commercialized during the 1990s and would be capable of (1) significantly reducing the emissions of SO_2 from existing facilities in order to minimize environmental impacts such as transboundary and interstate pollution and/or (2) providing for future energy needs in an environmentally acceptable manner.

1.6.2 Legal Basis for Authority to Expend Funds

The expenditure of DOE funds under this cooperative agreement is subject to the requirements of Public Law 100-446. Except as otherwise expressly provided in Public Law 100-446 or by terms of this cooperative agreement, the parties are complying with the applicable provisions of Subparts A, B, and C of the DOE Financial Assistance Rules, 10 CFR Part 600.

1.7 PROPRIETARY INFORMATION

Bechtel considers certain process data to be proprietary and confidential. These data cover the following six design areas:

- Piping arrangement for the lime slurry supply and return
- Modifications required to standard nozzles to adapt them for use in the CZD system
- Arrangement of the nozzles in the duct
- Longitudinal and transverse temperature profiles in the duct when the nozzles are operational
- Material flow rates and operating pressures
- Instrumentation, control, and arrangement of the control system

Process flow diagrams, piping and instrument diagrams, sketches, tables, graphs, and other illustrations showing information relating to any of the above six design areas are considered Bechtel proprietary technical information. As appropriate, Bechtel has excluded any proprietary information from this Public Design Report.

Figure 1-1
PROJECT ORGANIZATION AND PARTICIPANTS

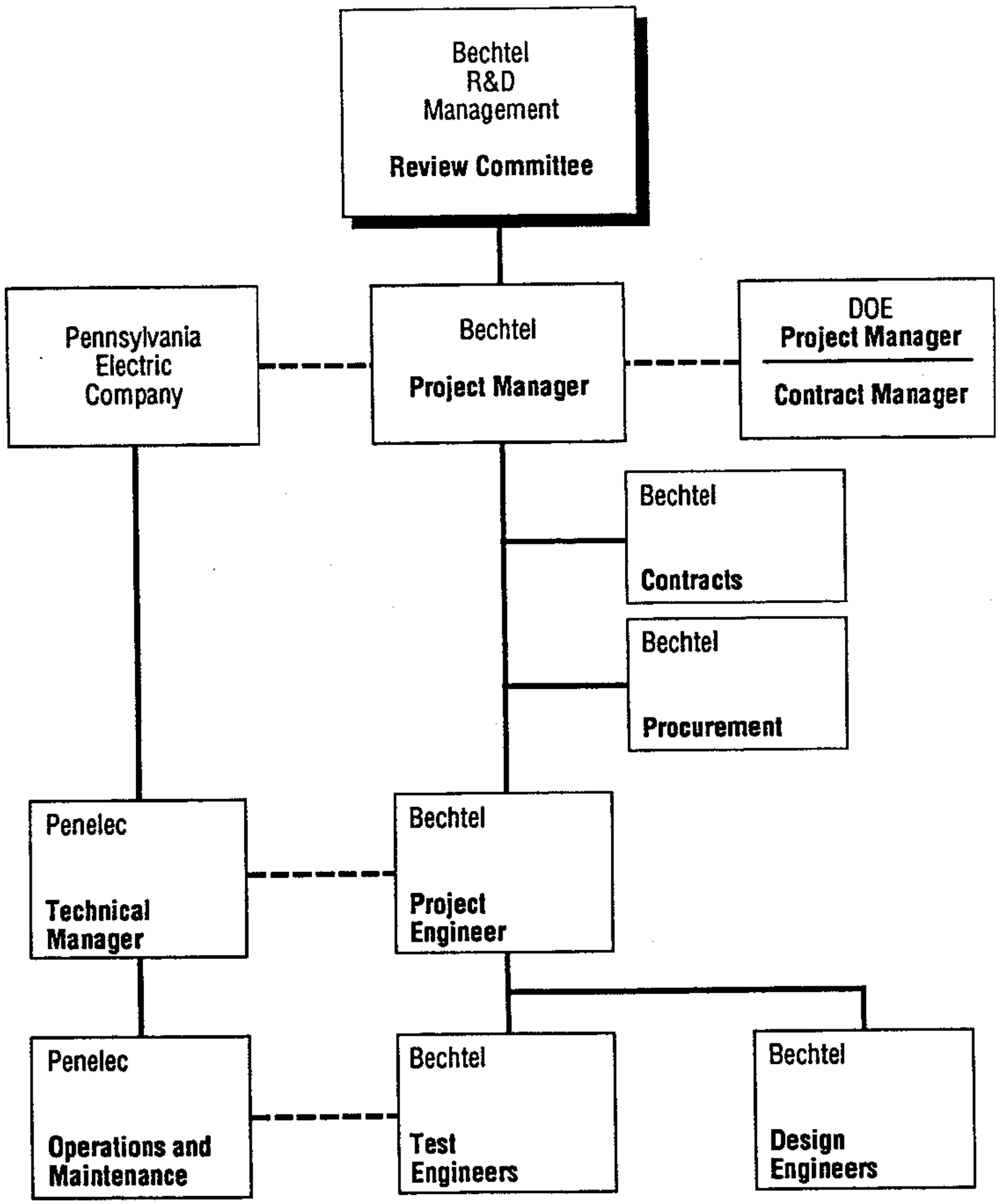


Figure 1-2
RELATIONSHIP BETWEEN PARTICIPANTS

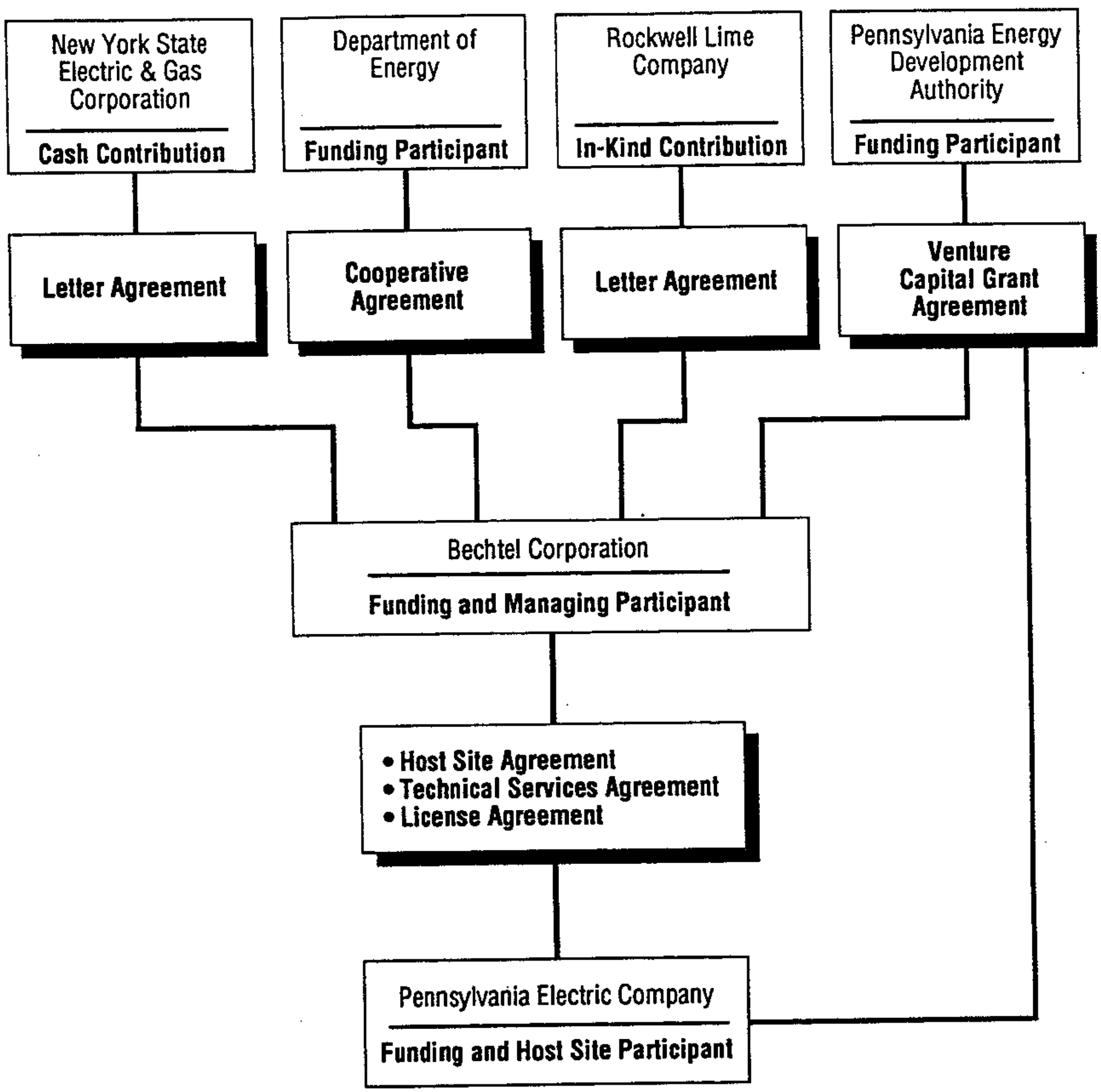
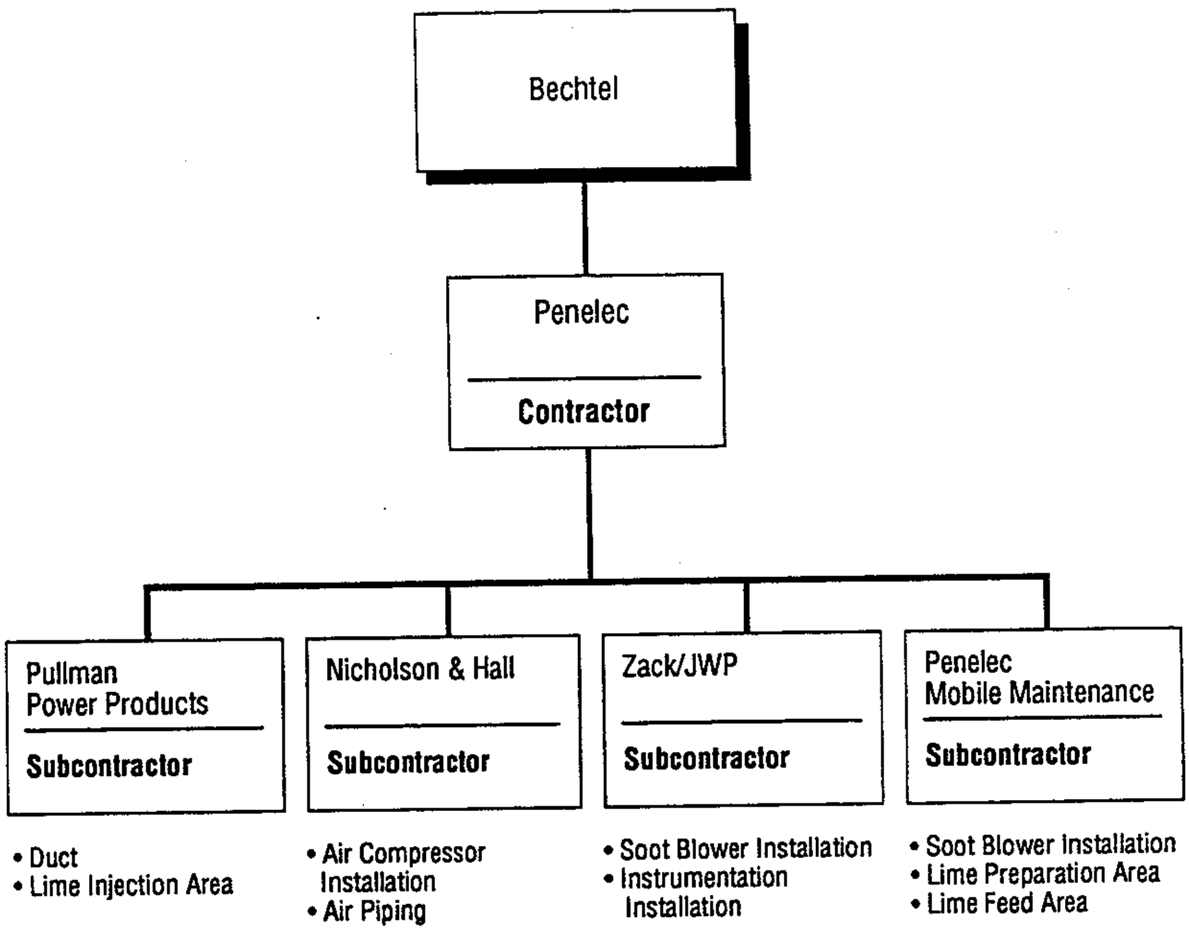


Figure 1-3
CONTRACTOR AND SUBCONTRACTORS



2.0

Overview of Project

2.0 OVERVIEW OF PROJECT

2.1 PLANT AND SITE CHARACTERIZATION

2.1.1 General

In this project – a demonstration of confined zone dispersion flue gas desulfurization (CZD Project) – a slurry of lime will be injected into the ductwork to investigate the use of CZD to reduce the emissions of sulfur dioxide (SO_2) to the atmosphere. As a part of DOE's Clean Coal Technology (CCT) Program, DOE is cofunding the CZD Project in cooperation with the project participant, Bechtel, the host utility, Pennsylvania Electric Company (Penelec), and other cofunders.

The objective of this project is to demonstrate that 40 to 50 percent SO_2 removal can be achieved through application of the CZD process. Solid waste generated by the CZD Project will consist of reacted products, unreacted lime, and inert material from the lime (grits). The solid waste will be transported to a permitted landfill. The liquid waste (10 gpm), which will contain lime residues, will flow into the plant wastewater treatment facility.

2.1.2 Project Location

The Seward Station, site of the CZD Project, is located in western Pennsylvania, approximately 12 miles northwest of Johnstown on the southern bank of the Conemaugh River in East Wheatfield Township, Indiana County. Figure 2-1 shows the property boundaries of Seward Station, which is owned and operated by Penelec. The layout of Seward Station is shown in Figure 2-2. (All figures in Section 2 are presented at the end of the section.)

2.2 PLANT FACILITIES

2.2.1 General Description

2.2.1.1 Process Description

The CZD process involves the injection of a lime slurry into the flue gas ductwork located between a boiler's air heater(s) and particulate removal equipment. In the presence of water, SO_2 from the flue gas is absorbed as sulfurous acid, which, when exposed to lime, reacts to produce calcium and/or magnesium sulfites and sulfates, which are subsequently removed by the downstream particulate removal equipment. Some removal of oxides of nitrogen (NO_x) may occur because of the presence of the magnesium hydroxide in the dolomitic lime. This magnesium hydroxide reacts with sulfurous acid to produce magnesium sulfite, which favors the removal of NO_x. The precise chemical mechanism for NO_x removal is not well understood at this time.

In the CZD process, the wet reaction particles and unreacted lime must dry before contacting the duct turning vanes, particulate removal equipment, etc., or they will adhere to these surfaces and cause unwanted deposit buildups which could plug the duct and thus affect operations. To prevent this from occurring, the prepared lime slurry is injected close to the center of the flue gas duct, parallel to the flow of gas. The use of narrow-angle sprays and carefully positioned atomizers makes it possible to obtain a wet zone in the middle of the duct for SO_2 removal while maintaining an envelope of hot gas between the wet zone and the duct wall. This is the principle of the confined zone, as shown in Figure 2-3. As the cone of spray moves downstream and expands, the gas within the cone cools and the reacted lime slurry on the outside of the cone mixes with the hot gas and dries rapidly. If the proper slurry concentration and injection rate are employed, drying is complete before the droplets contact the walls of the duct. Approximately 90 to 95 feet downstream of the injection point, the free moisture in the spray completely evaporates, and the dry solid contacts the duct and the turning vanes without adhering to them. The dry reaction particles and the unreacted lime are then removed by the ESP, along with the fly ash.

2.2.1.2 Application of the Process in the Project

The CZD process is being demonstrated on Seward Station's Unit 5. Unit 5 is a 147 MW utility unit, with two flue gas ducts, each serving a capacity equivalent to 73.5 MW. Each duct is connected to a chamber of the first-stage ESP and a chamber of the second-stage ESP. Both ESPs are located downstream of the air heaters. One of the two flue gas ducts leading from the unit will be retrofitted with CZD equipment, as shown in Figure 2-4. The installation of the CZD equipment required that the B duct be replaced with a 211-foot-long duct, which includes a 120-foot-long straight section, to permit a lime slurry retention time of 2 seconds and the addition of atomizers.

During the CZD Project, Unit 5 will be operated as usual. At present, Unit 5 consumes an average of 65 tons/hour (tph) of bituminous Somerset County coal. The composition of the coal is approximately 13.63 percent ash, 1.54 percent sulfur, and 6.21 percent moisture, with a heating value of 12,200 Btu/lb. The overall quantity of coal burned in relation to the megawatt-hours of production is not expected to show an increase during CZD operation.

Three types of lime will be tested during the project: pressure-hydrated dolomitic lime (PHDL), and two forms of calcitic lime (CL) (dry hydrate and freshly slaked slurry of CL). Hydrated dolomitic and calcitic lime in powder form will be pneumatically unloaded from trucks into the lime silo. The lime silo and lime sump are existing components of Seward Station, which, in addition to supplying lime slurry for treating the station's wastewater, will be used for preparing lime slurry for the operation of the CZD Project. From the lime sump, the lime slurry will be pumped to degritting equipment, which will feed the lime slurry feed tank. The freshly slaked slurry of CL will bypass the lime silo and lime sump and will be pumped directly from trucks to the degritting equipment.

Freshly slurried lime contains abrasive grits that do not react with SO_2 and can plug the atomizing nozzles. These grits will be removed from the slurry by the degritting equipment, which consists of a vibrating screen that separates grits from the lime slurry and two agitated grits slurry tanks (one spare). From the degritting equipment, the lime slurry will be fed into lime slurry feed tanks.

From the tanks, the lime slurry will be pumped into the atomizing nozzles, installed inside the flue gas ducts. For supplying the lime slurry to the atomizing nozzles, the CZD Project has two agitated lime feed tanks, two lime feed pumps, and a lime slurry loop main interconnecting the feed pumps to the atomizing nozzles. As shown in Figure 2-5, air-atomizing nozzles are mounted in the flue gas duct of the lime slurry atomization system. (In the figure, all the major areas, except the flue gas desulfurization area, are shown cross-hatched to make the latter stand out.) Compressed air will be used to produce a finely atomized lime slurry mist inside the flue gas duct. The reacted products, together with the dry fly ash, will be removed from the flue gas by the second-stage ESP.

2.2.1.3 Simplified Block Flow Diagram

Figure 2-6 represents a simplified process block flow diagram of the proposed CZD-FGD plant. Figure 2-7 represents a bulk materials flow diagram of the proposed CZD-FGD plant.

2.2.1.4 Plot Plan

Figure 2-8 represents the proposed plot plan of the facility. The only equipment that occupies additional land area within the plant is the duct extension.

The balance of equipment is located within existing structures.

Atomizing air equipment is located on the turbine deck, with the air receiver between the turbine deck and the basement.

Lime slurry preparation activities and equipment will be at the lime sump, which is located within the water treatment building.

The lime feed area is located under the B duct at the transition from the first-stage ESP.

The lime slurry injection area is located on top of the B duct over the transition from the first-stage ESP.

2.2.1.5 Plant Photographs

Figures 2-9 through 2-32 show various views of the facility, as designed.

2.2.1.6 Material Balance and Energy Consumption

The expected material balance and energy consumption are given in Figure 2-33. The design conditions are based on an ambient temperature of 60°F and an ambient pressure of 14.7 psia. The sulfur content of the coal burned at Seward Station varies from 1.5 to 1.6 percent.

2.2.1.7 Environmental Control Provisions

Estimates of the gaseous, liquid, and solid emissions from the CZD-FGD plant will be filed with the State of Pennsylvania, Department of Environmental Resources.

2.2.1.7.1 Particulate Emissions

The CZD-FGD plant will increase the quantity of particulate matter flowing to the ESP of Unit 5. The ESP will remove these particulates with the fly ash. Particulate emissions to the atmosphere should not increase above normal plant operating levels or exceed levels specified in the permit. Therefore, no impacts with respect to particulate emissions are expected.

2.2.1.7.2 Cooling Water

Seward Station currently uses 216 million gallons per day (mgd) of cooling water from the Conemaugh River. Cooling water is pumped once through the condenser tubes, which cool the steam from the turbines. The cooling water does not come into direct contact with the boiler water and flows directly back into the Conemaugh River. River water is also used to make up losses from the wastewater treatment plant and for sluicing the refuse material from the pulverizers of Unit 5. The cooling water for the CZD atomizing air compressors will be supplied by the cooling tower, makeup water for which is supplied by the local water company.

2.2.1.7.3 Surface Drainage

Coal pile runoff is collected in ditches around the coal pile, which feeds into the outside drainage system shown in Figure 2-34. The east-side drainage system conveys flows entering the yard drains on the east, north, and south side of the plant to the east yard sump. The east yard sump is 10 ft (height) x 12 ft (width) x 27 ft (length) and is equipped with two 450 gallon-per-minute (gpm) pumps. The west-side drainage system conveys flows entering the yard drains on the west, southwest, and northwest sides of the plant to the west yard sump. The west yard sump has two 10 ft (height) x 10 ft (width) x 30 ft (length) compartments which can be valved to feed the sump one at a time. The sump is also equipped with two 250 gpm pumps. Both sumps pump the flow to the waste treatment facility. During heavy rains characteristic of a 10-year 24-hour precipitation event, the overflow runoff collected in the sumps is discharged directly to the Conemaugh River.

2.2.1.7.4 Wastewater Treatment Facility

Treatment of all station drainage flows consists primarily of neutralization with lime and sedimentation in a 150 ft dia. clarifier with a capacity of 1.05 mgd. The hydrated lime used for neutralization is stored in a 50-ton storage silo. A baghouse on top of the lime storage silo filters the air vent, preventing the lime powder from escaping into the atmosphere during the transfer of lime from a truck to the lime silo. The lime is screw-fed, on demand, into a 10,000-gallon lime slurry tank. The slurry is pumped to a feeder on top of the tank, where it flows by gravity into a collection box. Wastewater from the plant operations and the outside drainage sumps flows into the collection box and is mixed with the lime slurry. The neutralized wastewater then flows into the clarifier, where the sediment is removed.

The clarifier is equipped with two oil skimmers and rotating rakes. The rotating rakes push the sludge to the center well, which is a suction point for two parallel sludge pumps. The sludge pumps pump the sludge back to the dewatering bins. From the clarifier, the treated wastewater flows by gravity to a clearwell, and stored there. The treated wastewater is then recirculated back into the station, where it is used for ash sluicing.

The storage capacity of the clearwell is often exceeded as a result of seasonal rains and overflows are discharged to the Conemaugh River. During heavy rains characteristic of a 10-year 24-hour precipitation event, the treated wastewater overflow from the clarification pond is also discharged to the Conemaugh River. These discharges are within Seward Station's National Pollutant Discharge Elimination System (NPDES) permit provisions.

2.2.1.7.5 Outfalls to the Conemaugh River

Seward Station has 10 outfalls discharging to the Conemaugh River under NPDES permit provisions. These outfalls are shown in Figure 2-35. Table 2-1 indicates the source associated with the wastewater discharge, the occurrence of the discharge and the maximum daily discharge rate, and the representative monthly discharge rates. The NPDES permit requires the plant to file monthly effluent water quality monitoring reports detailing flow rate, pH, total suspended solids (TSS), oil and grease, and biochemical oxygen demand (BOD) for the effluent from Outfalls 002, 003, 004, 005, and 006.

Treated wastewater from the treatment plant is circulated back into the station, where it is used for bottom ash sluicing; i.e., water quenches the bottom ash allowing it to be transported to dewatering bins. When a dewatering bin is filled with solids, the water is first decanted off and the remainder is drained through the ash. This water then flows back to the wastewater treatment facility.

Seward Station also uses approximately 0.43 mgd of potable water, supplied by the High Ridge Water Company via pipeline. This water is used for cooling tower makeup water, for boiler water makeup, and for drinking water and sanitary purposes. Potable water losses associated with the cooling tower are through evaporation to the atmosphere and through the cooling tower water, which is used to lubricate and cool the intake pump bearings (pump bearing purge water) and is subsequently discharged to the river. Cooling tower blowdown is discharged with the pump bearing purge water.

The boiler water makeup, which is processed through the plant's filters, softeners, and evaporator, is constantly recirculated between the boilers, condensers, and deaerators. Boiler water blowdown, along with wastewater from the filters and softeners, is routed to the east yard sump, which discharges to the wastewater treatment facility. The potable water used for drinking and sanitary purposes is routed to a small sanitary treatment facility on site, which treats all of the station's sanitary waste, prior to its permitted discharge to the Conemaugh River.

2.2.1.7.6 Solid Waste Discharges and Management Systems

Solid waste streams from Seward Station include the bottom ash and fly ash as well as sludges from the wastewater treatment facility. Bottom ash is removed from the boilers and sluiced to dewatering bins. After a dewatering bin has been filled, the water is first decanted off and the remainder is drained through the ash. The relatively dry ash is then dumped through a large gate valve at the bottom of the conical-shaped bin into trucks, which transport the ash to the disposal site. Fly ash is collected by the plant's ESPs. After the ESPs have removed the fly ash from the flue gas, the ash is transported to the fly ash silo before being discharged directly into trucks for transport to the disposal area. Water is added to the fly ash at the silo to control dust and to facilitate compaction. The solid waste production of all three boilers, at maximum boiler load (90 tph bituminous coal containing 15 percent ash) is 10.8 tph of fly ash and 2.7 tph of bottom ash.

2.2.1.7.7 SO_2 Emissions

The CZD Project will have a beneficial impact on the environment by reducing the amount of SO_2 emissions. During the first phase of the CZD Project (6-month testing period), intermittent testing (lime slurry sprayed into the flue gas duct) will be conducted. In this testing period, significant amounts of SO_2 will be removed that might otherwise be released to the atmosphere. During the second phase of the project (6-month continuous operation of the CZD process), substantially more SO_2 will be removed from the flue gas stream, thus preventing the release of this SO_2 to the atmosphere. As a result, more than 1,000 tons of SO_2 will be removed from the plant flue gases during the 18-month project.

2.2.1.7.8 Solid Waste Disposal System

During the CZD Project, Unit 5 will be operated as it normally is and will discharge the same amount of fly ash and bottom ash from burned coal as it normally does. Solid waste generated by the CZD process will consist of reacted products, unreacted lime, and inert material from the lime grits. As described above, the lime grits will be discharged to the industrial wastewater treatment plant. The lime slurry injected into the flue gas will react with the SO_2 and NO_x. The reaction products will consist of calcium sulfite, calcium sulfate, magnesium sulfate, magnesium sulfite, calcium nitrate, and magnesium nitrate. The waste stream will also contain unreacted reagents (calcium hydroxide and magnesium hydroxide). The dry reaction products and unreacted reagents, together with the dry fly ash, will be removed from the flue gas by the second-stage ESP. The dry powder solid waste will be transported pneumatically from the ESP hoppers into a fly ash silo, from which the fly ash and reacted products will be discharged into special trucks which will haul the solid waste to a disposal area. To avoid fugitive dust emission during the unloading of the fly ash, a fine mist of water will humidify the powdery fly ash so that it has approximately 17 percent moisture content when transported and disposed of.

2.2.1.7.9 Utilities and Offsite Facilities

Additional energy requirements associated with the CZD Project will include electrical power to run the air compressors, new mixers in the existing slurry tanks, and pumps. The increase in electric power consumption for Seward Station is expected to be about 400 kW. An existing 4,160 V transformer will accommodate the additional energy requirements.

The production of lime slurry for the CZD technology should require approximately 60 gpm of water. The High Ridge Water Company provides potable water to Seward Station. The station currently uses approximately 300 gpm, and has a pressure capacity for up to 500 to 600 gpm.

Solid waste generated by the CZD Project will be transported to the existing permitted Conemaugh Coal Ash/Mine Refuse Disposal Area, where Seward Station's fly ash, bottom ash, and sludges are disposed of. The disposal area is approximately 2 miles west of the site. During the

18-month CZD Project, about 9,000 tons of reaction products will be disposed of in the landfill. The disposal site currently receives 2.28 million tons of waste per year.

2.2.1.7.10 Monitoring

Compliance monitoring will be conducted during all phases of the project: preconstruction (planning and design), construction, and operation. Compliance requirements will remain unchanged throughout the project and will be the same as current monitoring requirements under existing permits and state laws and regulations.

Supplemental monitoring will be performed during project operations, which will consist of a 6-month factorial test phase and a 6-month demonstration phase. The fundamental objectives of the supplemental monitoring program are to ensure that the CZD is safe for employees and the environment, and to develop an environmental and health database for the assessment and mitigation of impacts associated with the replication of the CZD Project. In addition, the supplemental monitoring program will be used to evaluate the success of the CZD Project. The criteria for success include:

- A CZD technology that does not adversely impact normal boiler operation and does not increase particulate emissions or percent opacity
- Removal of up to 50 percent of the SO_2 with up to 50 percent alkali utilization
- SO_2 removal costs of about $300/ton of SO_2

Data collected during this monitoring effort will yield a database for future reference. These data also will be used to generate quarterly and annual reports for the Pennsylvania Department of Environmental Resources (PaDER), DOE, and Penelec. A comprehensive quality assurance and quality control program will be followed for data received through the continuous emissions monitoring system (CEMS) and supplemental monitoring programs.

2.2.2 Plant Systems and Processes

2.2.2.1 Atomizing Air Compressors

The two 2,000 standard-cubic-foot-per-minute (scfm) oil-free, screw-type air compressors are located at the north side of the operating level adjacent to the plant service compressors. The indoor location requires air intake from outside the building. The compressors will feed a 5 ft-6 in. diameter x 15 ft long air receiver located between the operating floor and the basement.

An air line is routed through the basement to the CZD area located at the south side of the plant.

Cooling tower cooling water for the atomizing air compressors will be supplied from the plant cooling water system. It enters the plant at the northwest corner of the basement.

The emergency cooling water supply is from the house service water main. It enters the plant at the northeast end of the plant and is isolated from the cooling tower cooling water by a backflow preventer.

4,160 V power and 480 V control power are fed to the compressors from the Unit 5 bus.

2.2.2.2 Lime Slurry Preparation Area

This area, located in the water treatment building, will be used for preparing lime slurry for transfer to the lime slurry feed area and for providing the lime slurry for pH adjustment in the water treatment area. It contains:

- A 50-ton lime silo for receiving and storing dry lime hydrate
- A vent baghouse filter on the top of the silo for preventing atmospheric emissions of hydrate
- An agitated lime hydrate slurrying sump
- Lime slurry sump pumps
- A variable-speed air lock for discharging the lime hydrate from the storage silo into the screw conveyor
- A screw conveyor feeding the hydrate into the sump
- Piping for feeding the lime slurry from the sump into the power plant water treatment plant for pH control
- Piping for transferring the lime slurry from the sump to the lime slurry feed area
- Control instrumentation for:
  - Addition of water to the sump to maintain a constant slurry level in the sump
  - Addition of lime hydrate to the sump to maintain a constant concentration/density of the sump slurry.

The lime sump inventory will be maintained constant by the sump level controllers.

The upgrading of the existing lime handling equipment involves the replacement of the existing sump pumps by the larger sump pumps, the replacement of the fixed-speed driver of the silo's air lock rotary discharge valve with the variable-speed drive, and the addition of lime transfer piping and control instrumentation. The control instrumentation includes the sump level controller, which will control the addition of slurrying water to the sump, and the slurry density controller, which will control the feed of hydrate to the sump.

The existing lime silo has about 1 day of gross storage capacity for hydrate, which is adequate for the operation of the CZD system with daily lime deliveries.

2.2.2.3 Lime Slurry Feed Area

The lime slurry feed area is located on the ground under the discharge plenum from the first-stage precipitator. It contains two agitated lime slurry feed tanks, two lime slurry feed pumps, and the lime slurry feed loop main. Only one of the two lime slurry feed tanks will be used during the continuous system operation; the second feed tank will be required for factorial testing and will be used as a spare during operation.

A vibrating screen, located on the second level, will feed the lime slurry feed tanks by gravity. The flow to the vibrating screen will be controlled by the tank level controls, which will modulate the flow control valve in the lime slurry transfer line.

Each lime feed tank is equipped with a level sensor. The controller will be switched to the level sensor in the active lime tank. This sensor will control the transfer of the lime slurry from the lime slurrying sump to the vibrating screen from which the filtered slurry drains to the active feed tank. The tank is meant to operate full. It has 2 hours of storage capacity for emergency use in the event that normal operation of the lime slurrying system has to be interrupted for maintenance.

The feed loop piping contains the feed and return headers. The latter is fitted with a lime slurry back pressure controller to provide sufficient pressure in the lime slurry feed header that supplies the lime slurry to the atomizers.

The two lime feed pumps, one working and one spare, are single-stage, horizontal, high-head, high-speed centrifugal pumps. They are equipped with expellers for preventing lime slurry seal leakages.

Once the system is started, the feed tank agitator will operate nonstop. The agitator motor or its gears may eventually fail. Normally, a provision should be made for rapid replacement of failed equipment, but on this project such a provision should not be necessary because of the presence of a second agitated feed tank.

The centrifugal lime slurry feed pumps have expellers and packed seals that are designed to leak some water to lubricate and cool the seals. This leakage tends to increase with time. Controlling the leakage will require periodic tightening of the seal gland till a point is reached at which the seal has to be repacked. Whenever the working pump is shut down, it will have to be immediately flushed with water and left full of water, except for the time required for repacking the pump seal.

2.2.2.4 Lime Slurry Injection Area

The lime slurry injection area is located on the top of the discharge plenum of the first-stage ESP at the inlet to the desulfurization duct. The station contains atomizers, mounted on lances attached to plates, and connected to the lime slurry and atomizing air supply headers.

The atomizers are connected to the atomizing air distribution header by individual feeders, each equipped with a flow indicator (glass rotameter), a pressure gauge, and an isolating valve. The atomizing air header is equipped with a pressure controller and with flow, pressure, and temperature indicators. The atomizers are also connected to the lime slurry distribution header by individual feeders, each equipped with a sealed pressure gauge and an isolating valve. The lime slurry supply header is equipped with a flow indicator and a pressure controller for controlling the lime slurry pressure in the distribution header.

The lime slurry injection rate will be controlled by cascading the C section (turning vane) thermocouple temperature through the lime slurry injection pressure controller.

The water supply line is connected to the lime slurry supply header through the ready/standby valve and is fitted with the water flow controller. The flue gas handling system will be cooled by injection of atomized water into the flue gas prior to lime slurry injection, and the atomizers will be flushed whenever lime slurry injection is interrupted.

The water or lime feed to the atomizers must not start until at least one of the two atomizing air compressors has been working for at least 1/2 hour without problems. (Compressor noise, discharge pressure, discharge temperature, cooling water flows, etc., must be checked and condensate drained from the air receiver and the air supply header to the atomizers before starting the atomization of water or lime slurry.)

A boiler trip will require immediate shutoff of the lime feed to atomizers. This is done by activating the ready/standby valve to the standby position, shutting down the flow control valve from the power plant control room, closing the respective isolation valves, and shutting down the lime slurry feed and water booster pumps, and flushing the lime slurry feed pump and piping with water.

The lime injection rate will be controlled by the outlet flue gas temperature setpoint at the C section turning vanes. Automatic control will be accomplished by cascading the water flow controller and/or the lime slurry injection pressure controller. This arrangement prevents overcooling the flue gas by excessive injection in case of reduced boiler load and avoids an inadequate injection of lime slurry in case of increased boiler load.

The temperature of the flue gas at the inlet to the desulfurization duct will decrease with boiler load and ambient air temperature, reducing the total heat content of flue gas and its capacity for evaporating water from the atomized lime slurry. Injecting the lime slurry on the outlet flue gas temperature controller will prevent the flue gas from being overcooled because of the drop of its inlet temperature.

2.2.2.5 Duct and Soot Blowers

A section of the original duct was removed and replaced with a 211-foot-long duct, which includes a 120-foot-long section. The purpose of this replacement is to increase the residence time in the duct. The new duct addition spans the access road with a truss supporting structure.

Rotary soot blowers are provided in the bottom of the duct, spaced from the injection point to the turning vanes located at the first turn in the duct. There are 10 of these units. Retractable soot blowers are located on the turning vanes at the first corner in the duct. There are 4 of these units. The rotary soot blower will reentrain any particulate matter that prematurely deposits on the floor of the duct. The retractable soot blowers will remove deposits from the turning vanes and the thermocouples on these vanes. These thermocouples will be used to control the injection flow rate of lime slurry into the duct.

2.2.2.6 Winterization

The equipment was winterized in various ways. The lime slurry injection equipment, located on top of the duct, is enclosed in an insulated and removable structure with maintenance access panels having hinged viewing panels for access to individual instruments for direct readings or maintenance.

Piping between areas such as the lime slurry preparation area and the lime slurry feed area will be heat-traced and insulated to Penelec standards. Heat-tracing is installed on individual circuits using thermostats with built-in indicators to verify the POWER ON status.

The pump heads and any other sensitive equipment in the lime slurry feed area are enclosed in suitcase-type enclosures. The heaters are installed on individual circuits using thermostats with built-in indicators to verify the POWER ON status.

2.2.2.7 Instrumentation and Controls

The instrumentation and controls for the CZD-FGD system are installed at the Seward plant and parallel the operational divisions with respect to central control and monitoring.

In the lime slurry preparation area, the lime sump level and lime slurry density will be controlled and information transmitted from this area to the control room regarding the sump level, lime density, status of the lime-high-level and lime-low-level alarms for the lime silo, lime pumps run status, agitator run status, lime silo blower run status, lock hopper run status, and lime feeder screw conveyor run status.

The sump level, the lime density, and the position of the ready/standby valve may be adjusted/ controlled by the control room.

In the lime slurry feed area, the level of lime slurry in the tank will be controlled by throttling the control valve feeding the vibrating screen. The lime slurry feed pumps run status, vibrating screen run status, tank levels, and agitator run status will be recorded.

Duct instrumentation comprises skin thermocouples mounted below the nozzles, turning vane thermocouples mounted on the turning vanes, and two sets of 24 thermocouples mounted in the duct downstream of the first turning vanes to characterize the temperature profile in the duct. The signals from these thermocouples ~~is~~ are sent to the weather enclosure for recording, display, and signal processing before being sent to the control room for integration into the operation database.

The individual atomizers are each equipped with direct-reading individual rotameters and pressure gauges to quantify the operation of each atomizer lance. Airflow, lime slurry flow and pressures, and water flow and pressures are transmitted to the control room duct. Inlet and outlet gas flows and temperatures will be recorded in the weather enclosure and transmitted to the control room for inclusion in the operating database.

Operation and position reporting of the ready/standby valve will be accomplished either locally or remotely from the control room.

2.2.2.8 Electrical

The electrical upgrading of the plant to support the CZD-FGD system was a function of the location of the nearest electrical supply. The atomizing air compressor feeders were added to the Unit 5 main 4,160 V bus. A new motor control center (MCC) feeding the duct area was added to the Unit 4 bus, and the additional loads added in the lime sump area were incorporated into the local MCC that serves the water treatment building.

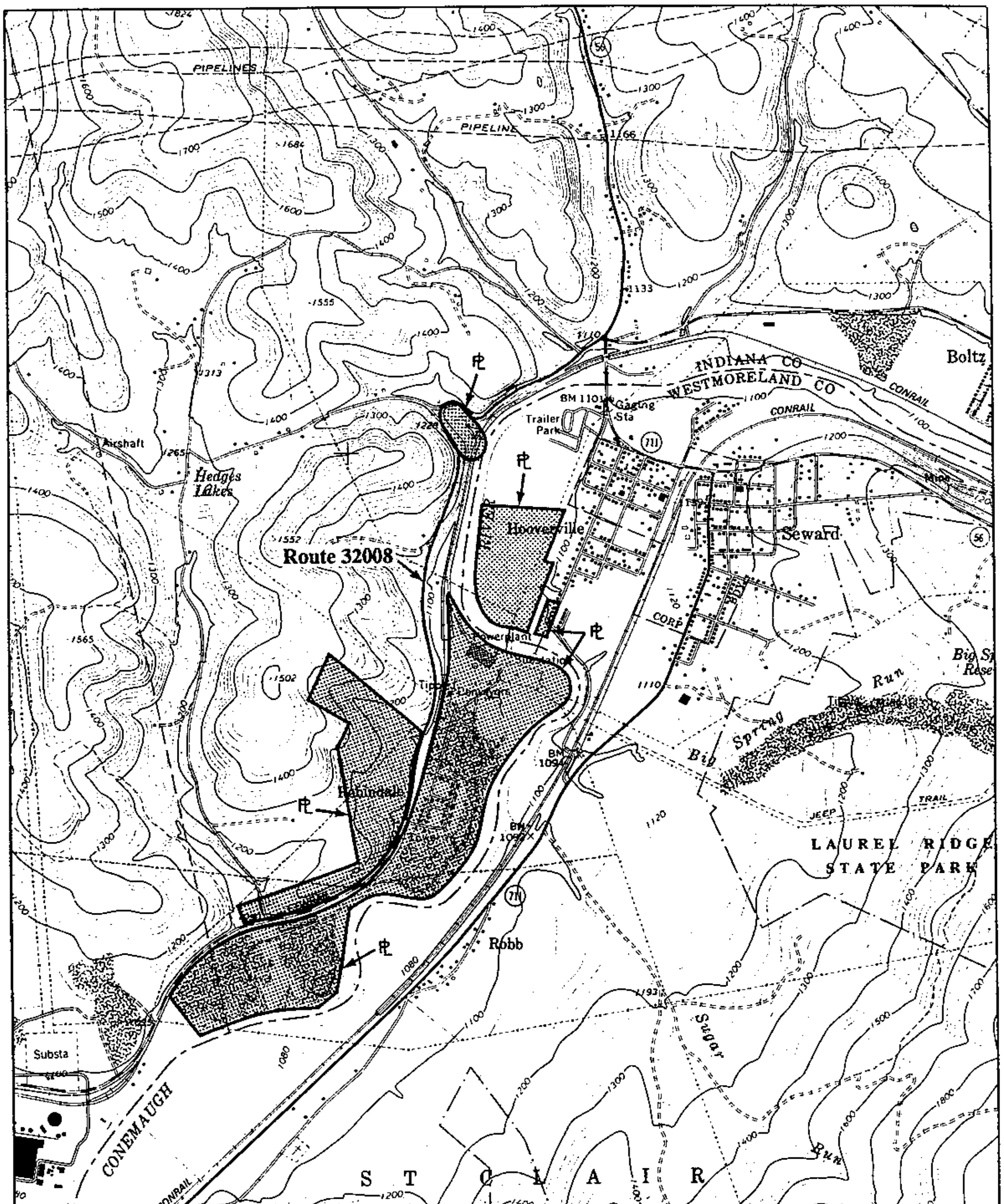
2.2.2.9 Piping and Mechanical

The only piping and mechanical equipment not covered in other areas is the lime slurry transfer line from the lime sump in the clarifier building to the lime slurry feed area located under the inlet of the duct extension.

2.2.3 By-Product

The by-product from the CZD-FGD system will be gypsum ($CaSO_4$). The by-product will be heavily contaminated with fly ash and hence not suitable for most commercial applications.

Figure 2-1
PROPERTY BOUNDARIES OF SEWARD STATION



(℄: Property Line)

Figure 2-2
SEWARD STATION SITE LAYOUT

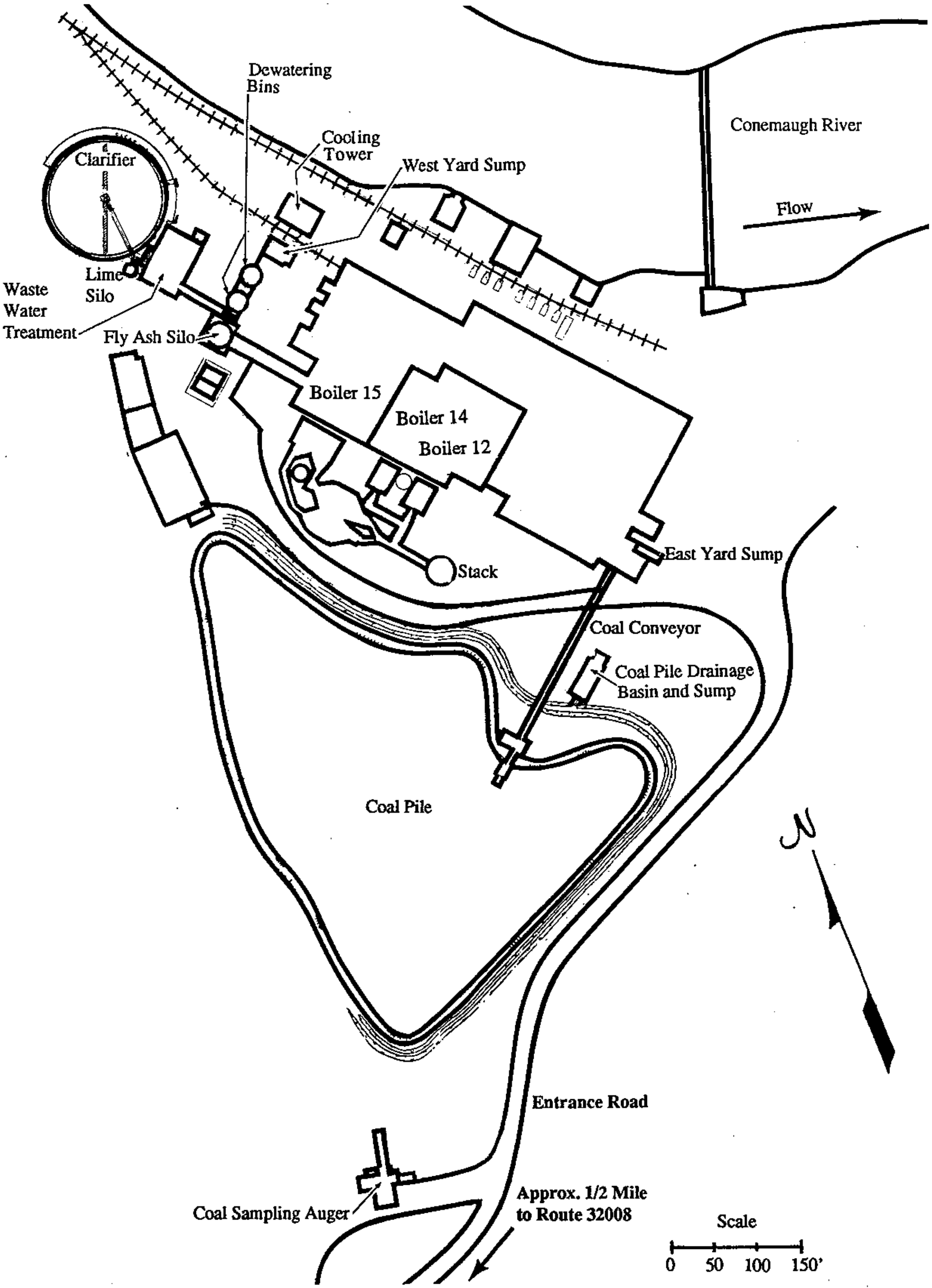


Figure 2-3
CONFINED ZONE DISPERSION DIAGRAM

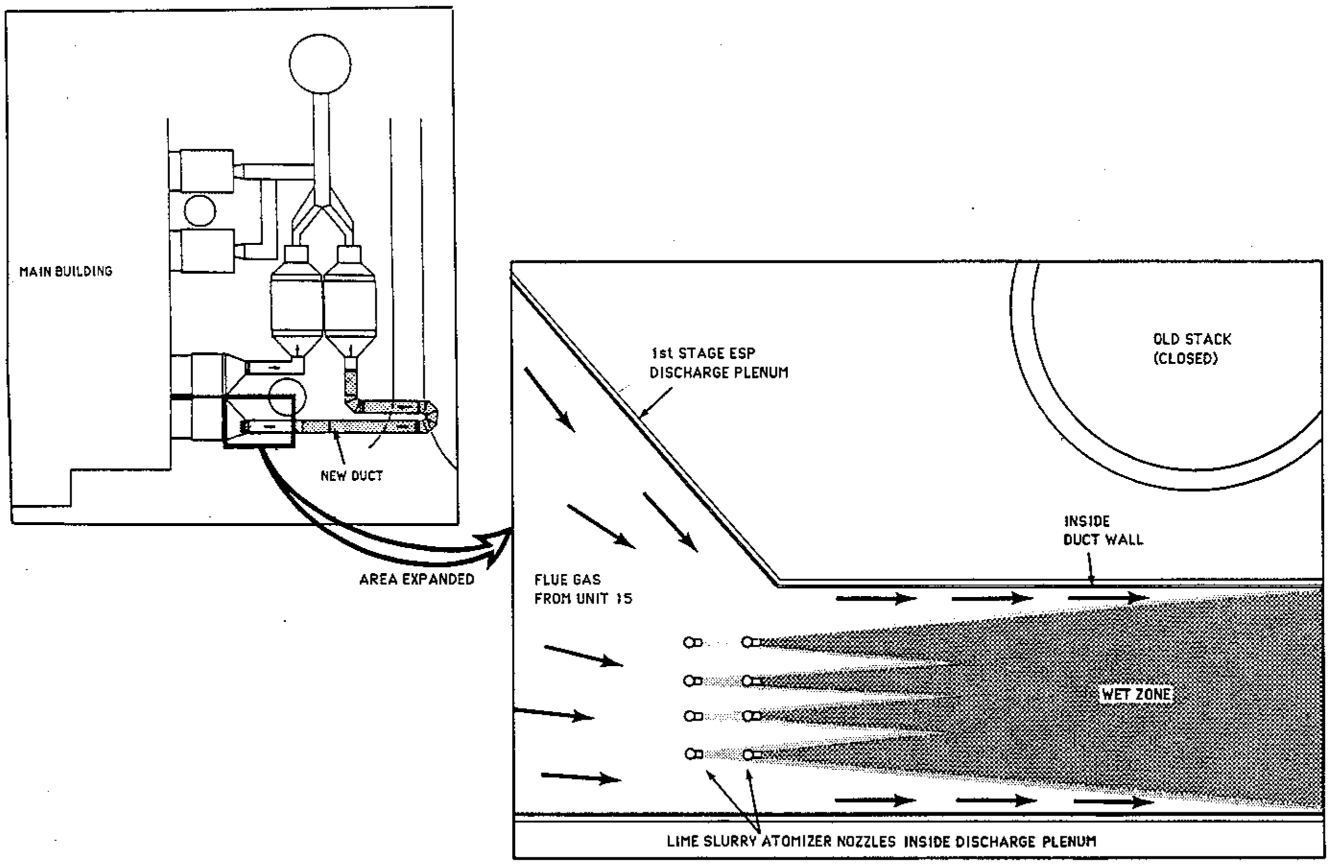
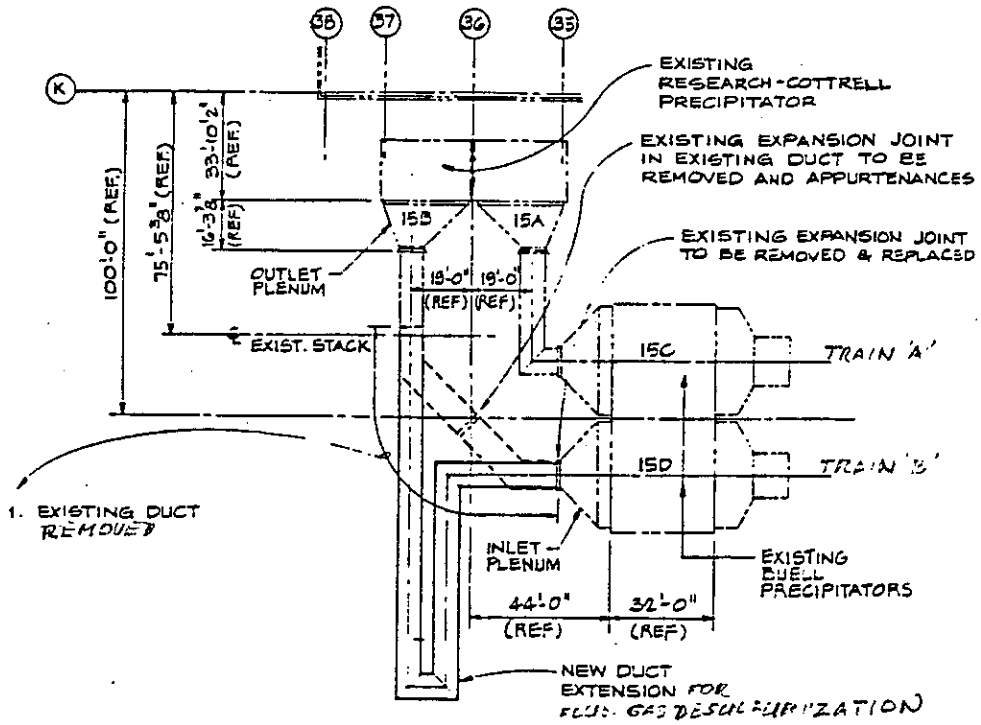
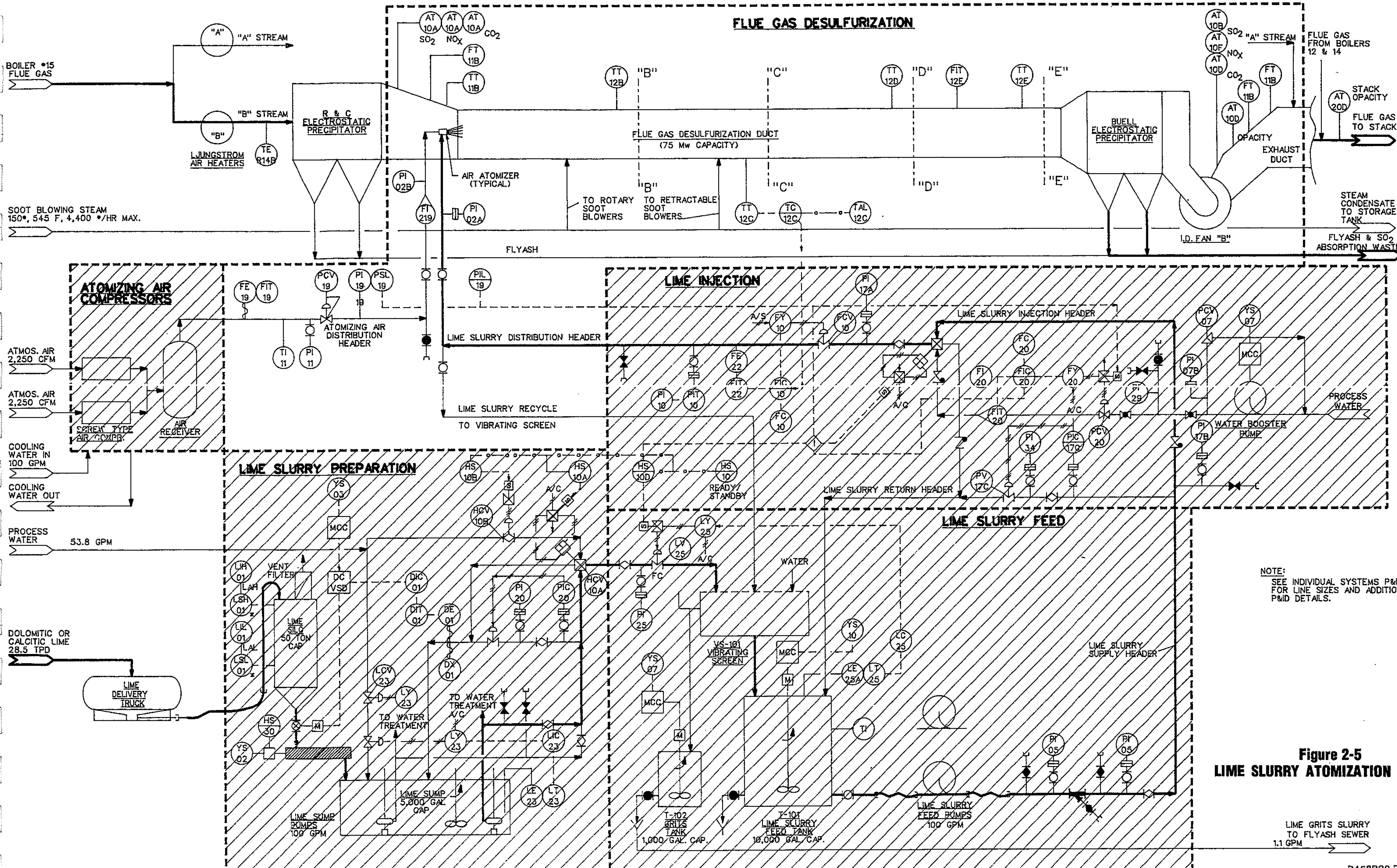


Figure 2-4
CZD GAS DUCT EXPANSION



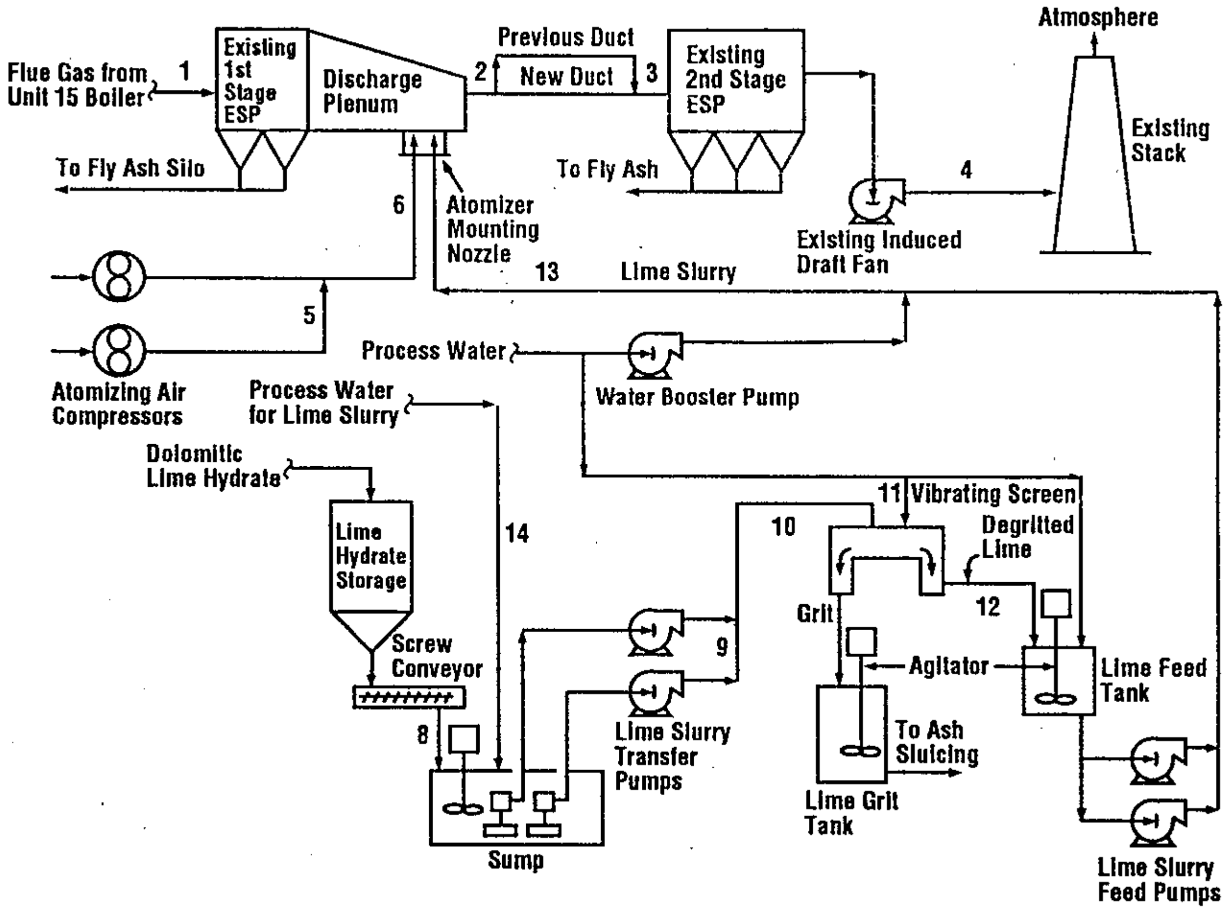


NOTE:
SEE INDIVIDUAL SYSTEMS P&ID'S FOR LINE SIZES AND ADDITIONAL P&ID DETAILS.

Figure 2-5
LIME SLURRY ATOMIZATION SYSTEM

B468B29.DGN

Figure 2-6
PROCESS BLOCK FLOW DIAGRAM



Note: Compositions of numbered streams are given in Figure 2-33.

Figure 2-7
BULK MATERIALS FLOW DIAGRAM

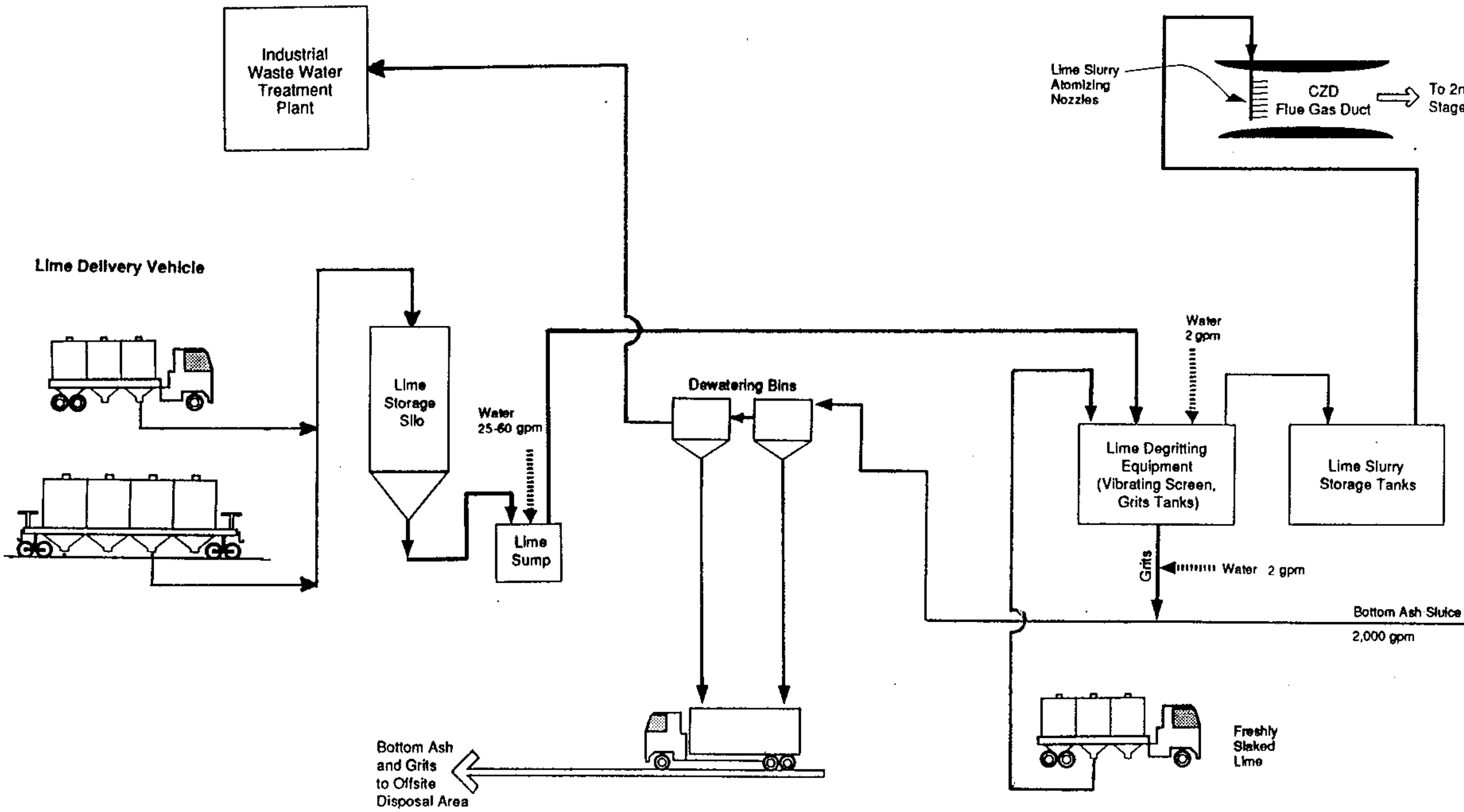


Figure 2-8
PROJECT LAYOUT

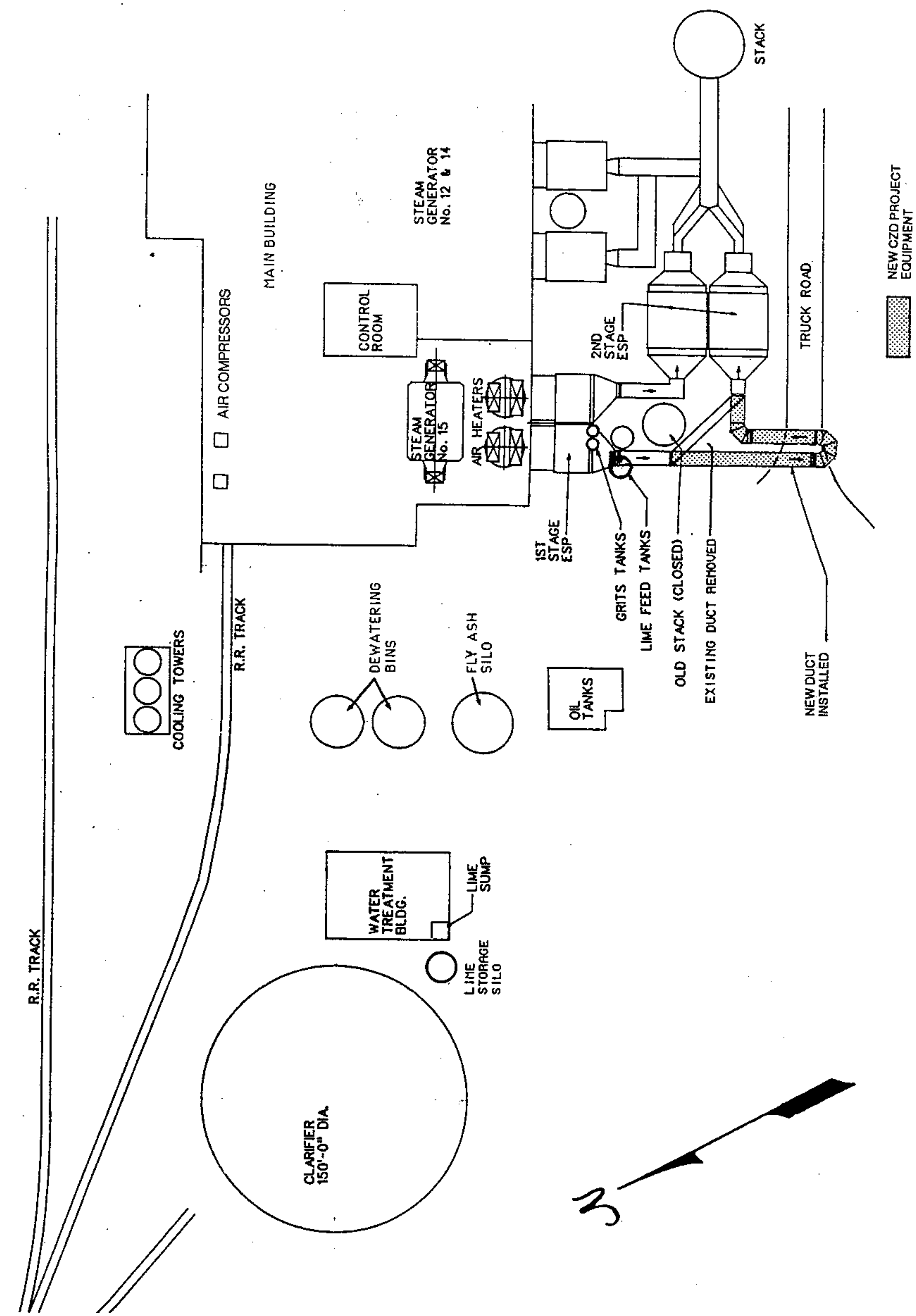


Figure 2-9
LIME SILO

The lime silo is located adjacent to the clarifier and the water treatment building.

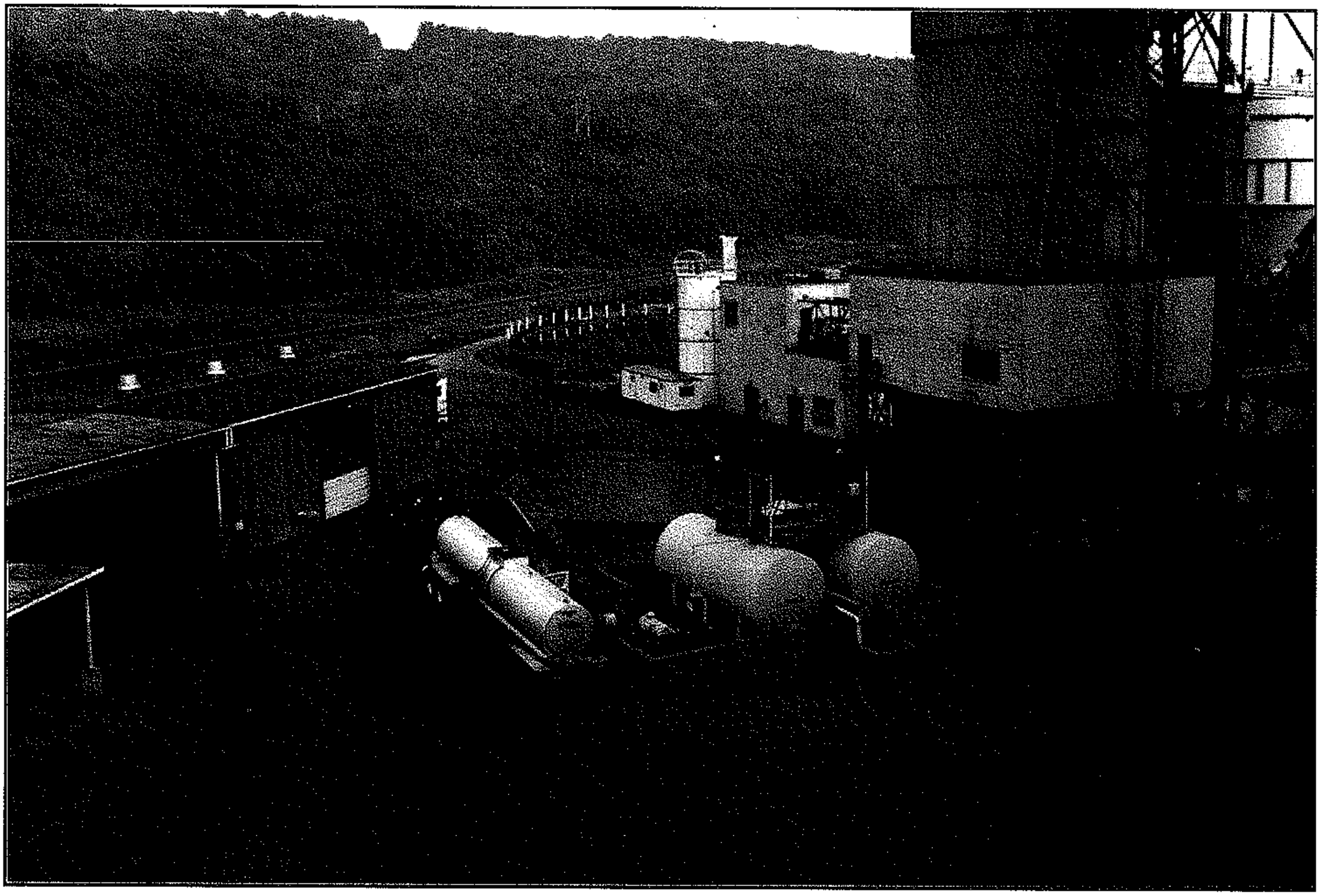


Figure 2-10
CONTROL PANEL FOR THE LIME SILO

This panel is used for control, monitoring, remote setpoint adjustment, and remote data logging for the lime silo. The panel provides the following functions:

- Lime high alarm
- Lime low alarm
- Lime silo vent filter
- Lime silo feeder
- Lime silo screw conveyor

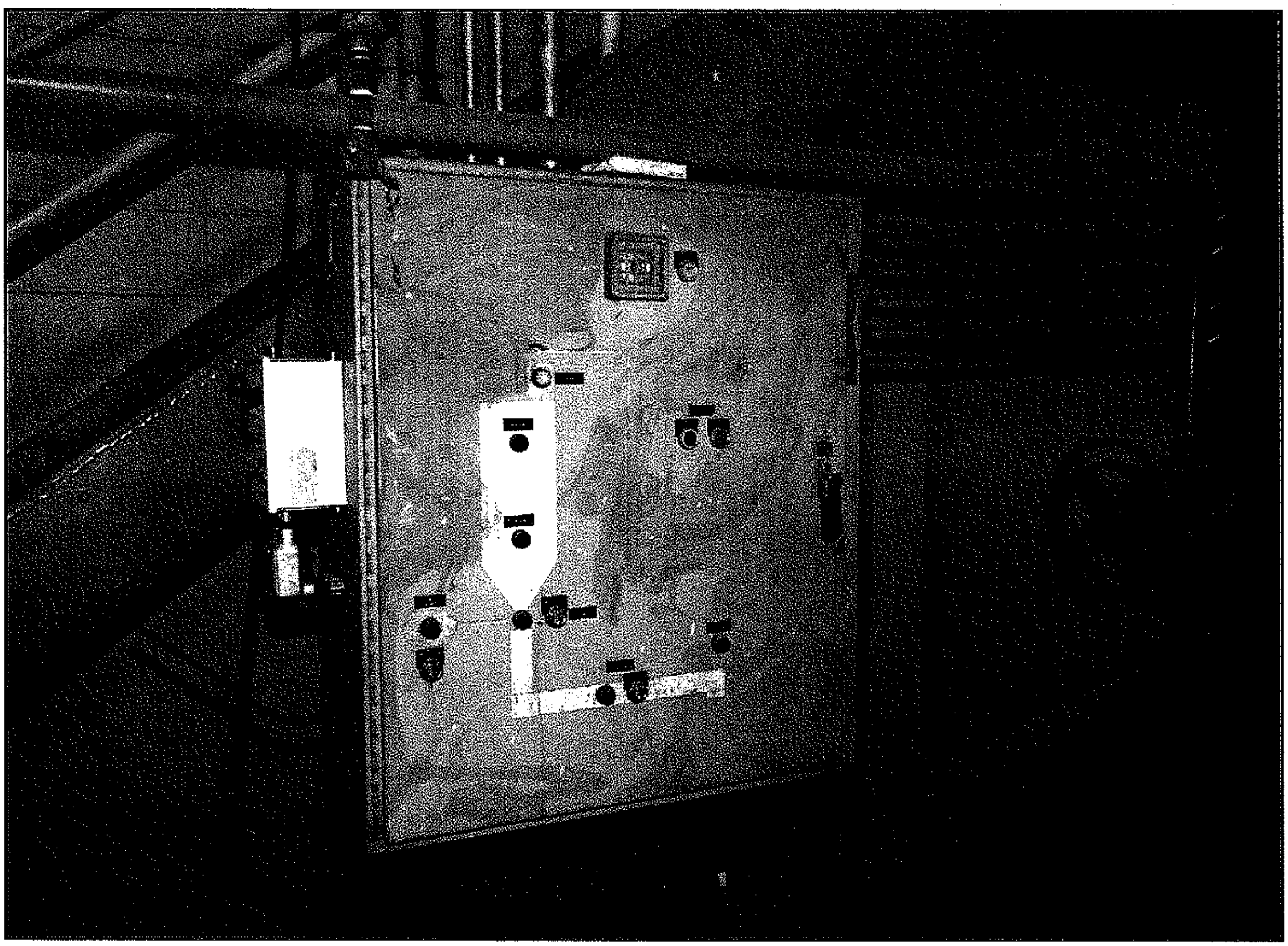


Figure 2-11
LIME SUMP, VIEW 1

Major features of this sump area include a screw conveyor, an agitator, a sump pump, and piping.

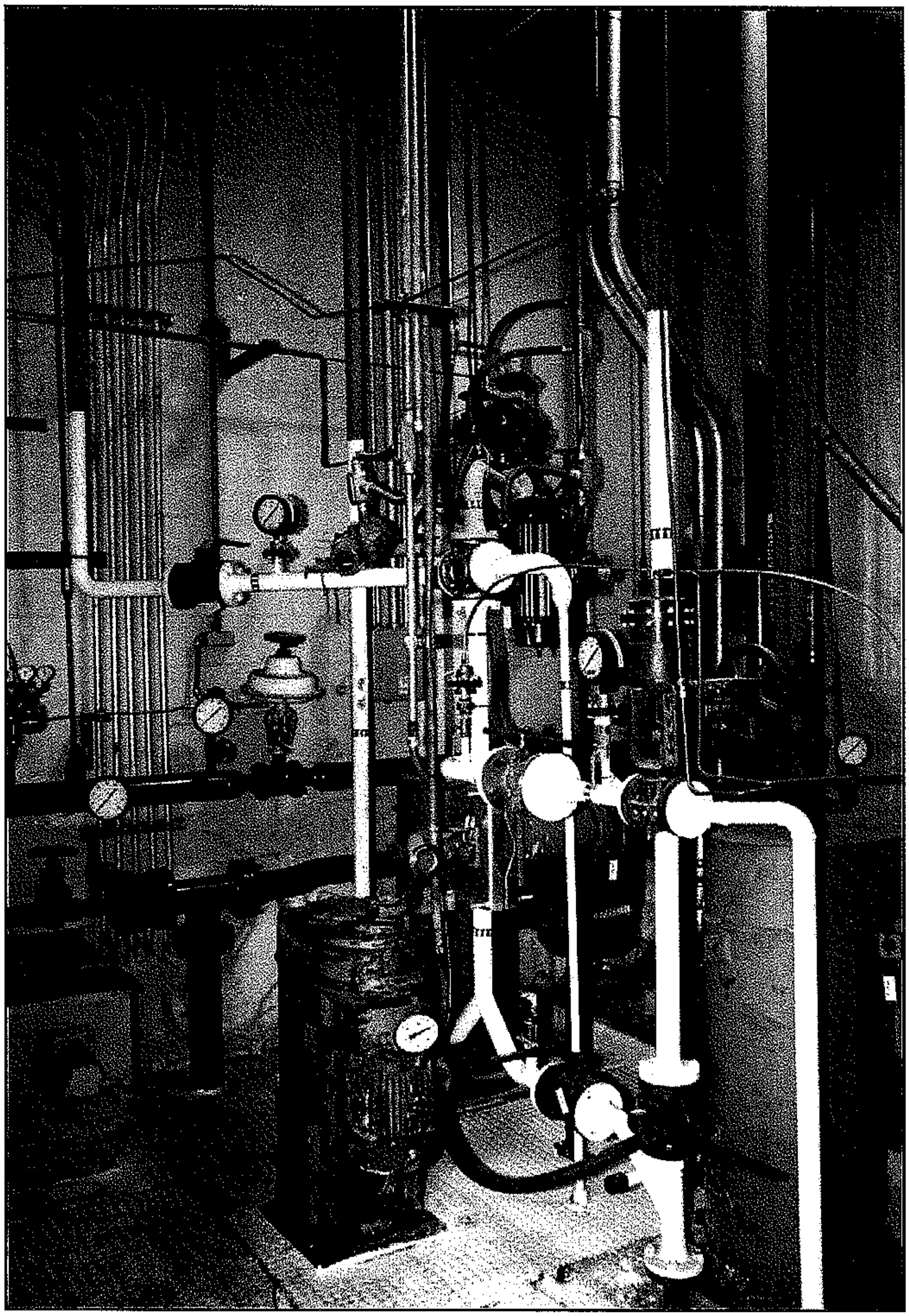


Figure 2-12
LIME SUMP, VIEW 2

Major features of the lime sump include two sumps, ready/standby valves, and a sump water fill valve.

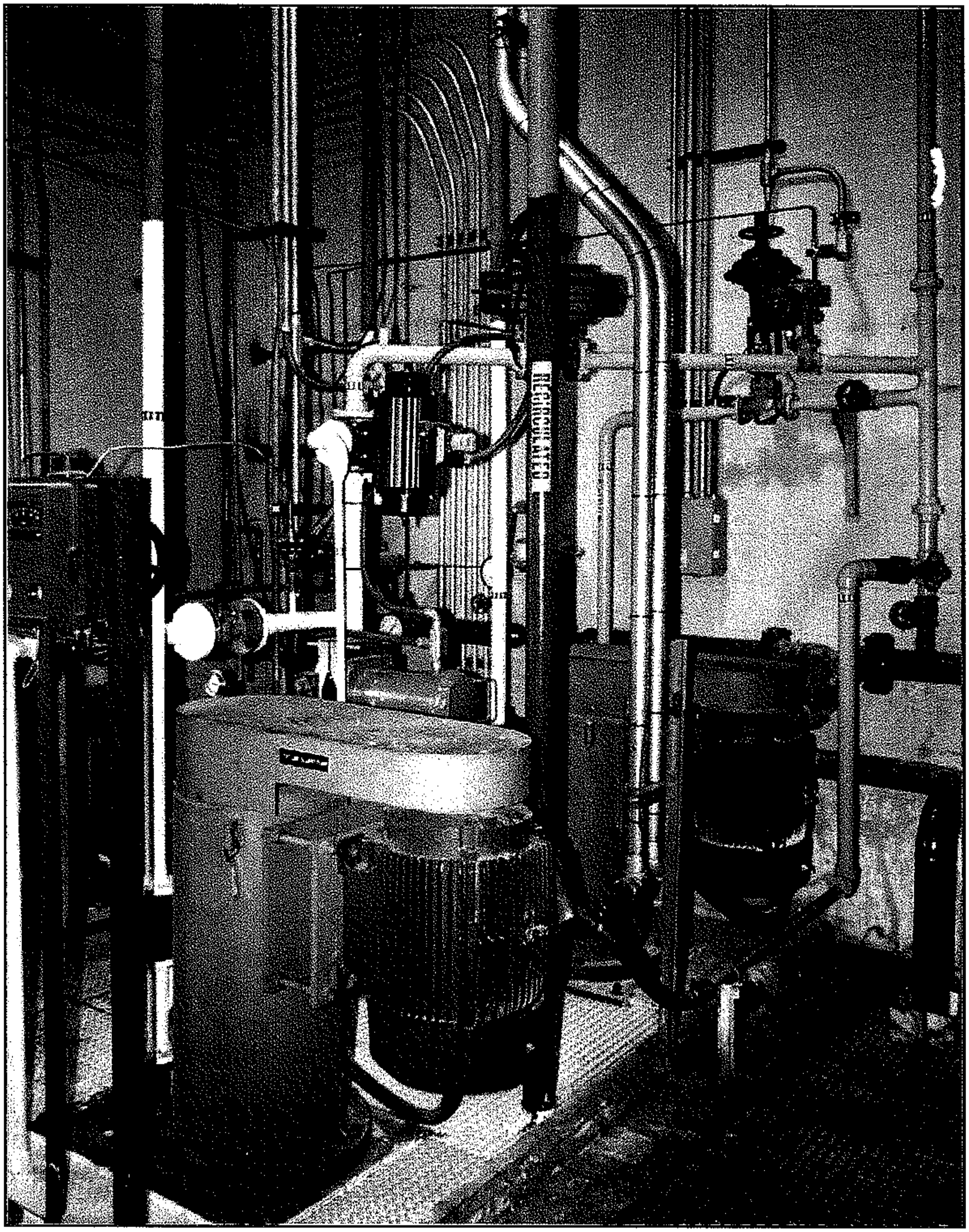


Figure 2-13
VIEW OF THE LIME SLURRY FEED AREA AT GRADE, VIEW 1

Major features of the lime slurry feed area include lime slurry storage tanks, grits storage tanks, lime slurry feed pumps, and starters, with a water booster pump shown in corner.

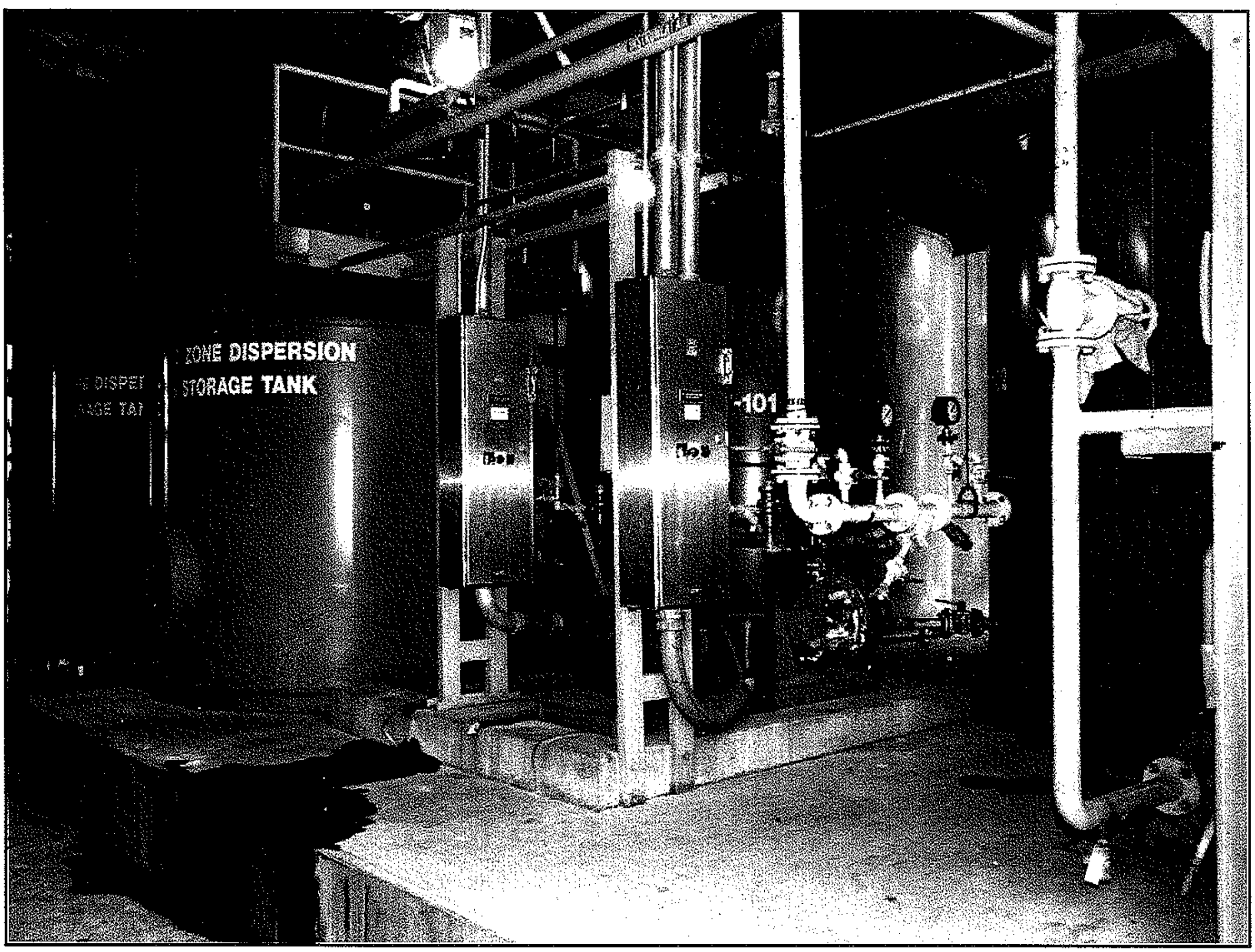


Figure 2-14
VIEW OF THE LIME SLURRY FEED AREA AT GRADE, VIEW 2

Major features include grits storage tank, lime slurry feed pumps, and lime slurry discharge header.

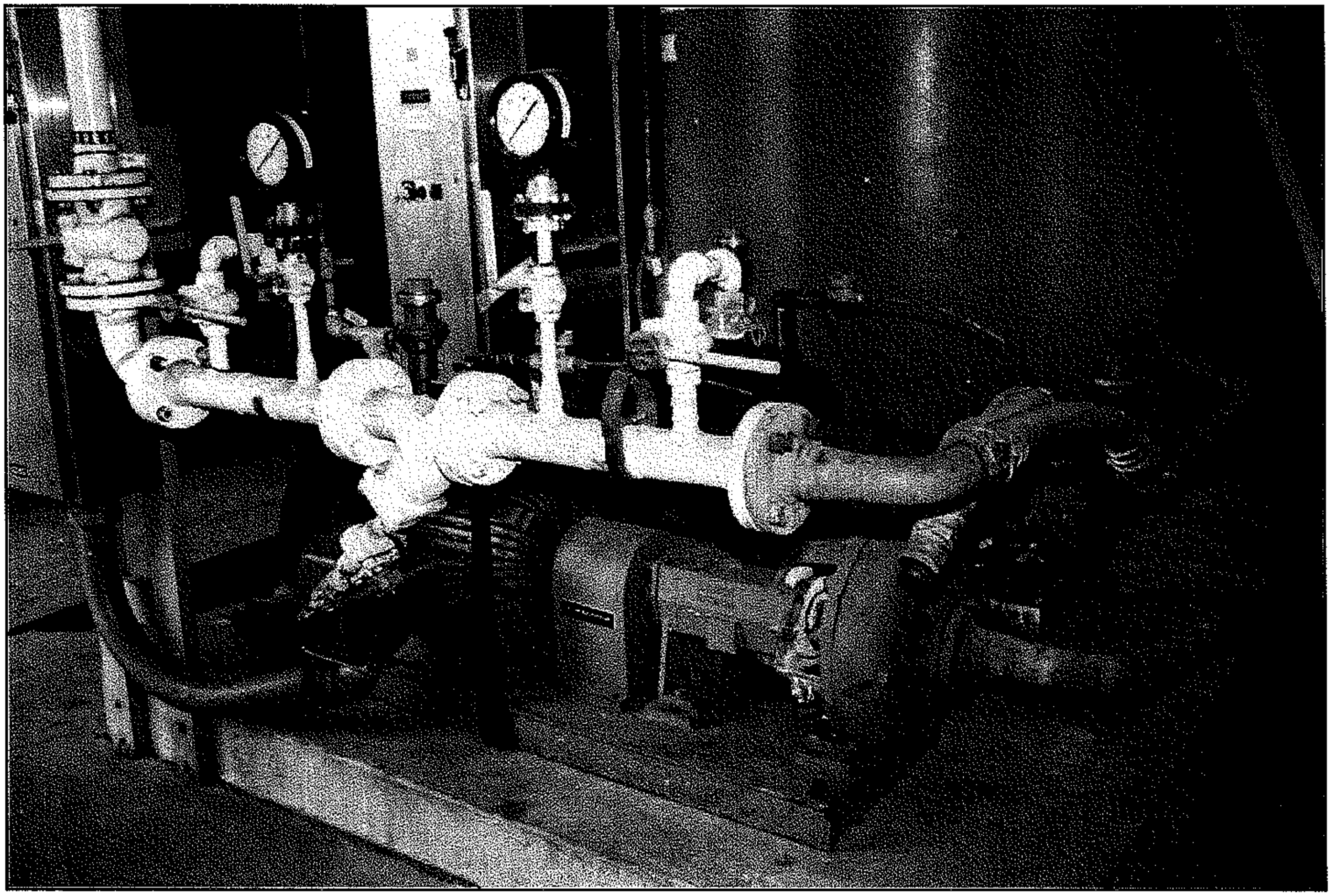


Figure 2-15
VIEW OF LIME SLURRY FEED AREA AT GRADE, VIEW 3

Major features include lime slurry feed pumps and piping.

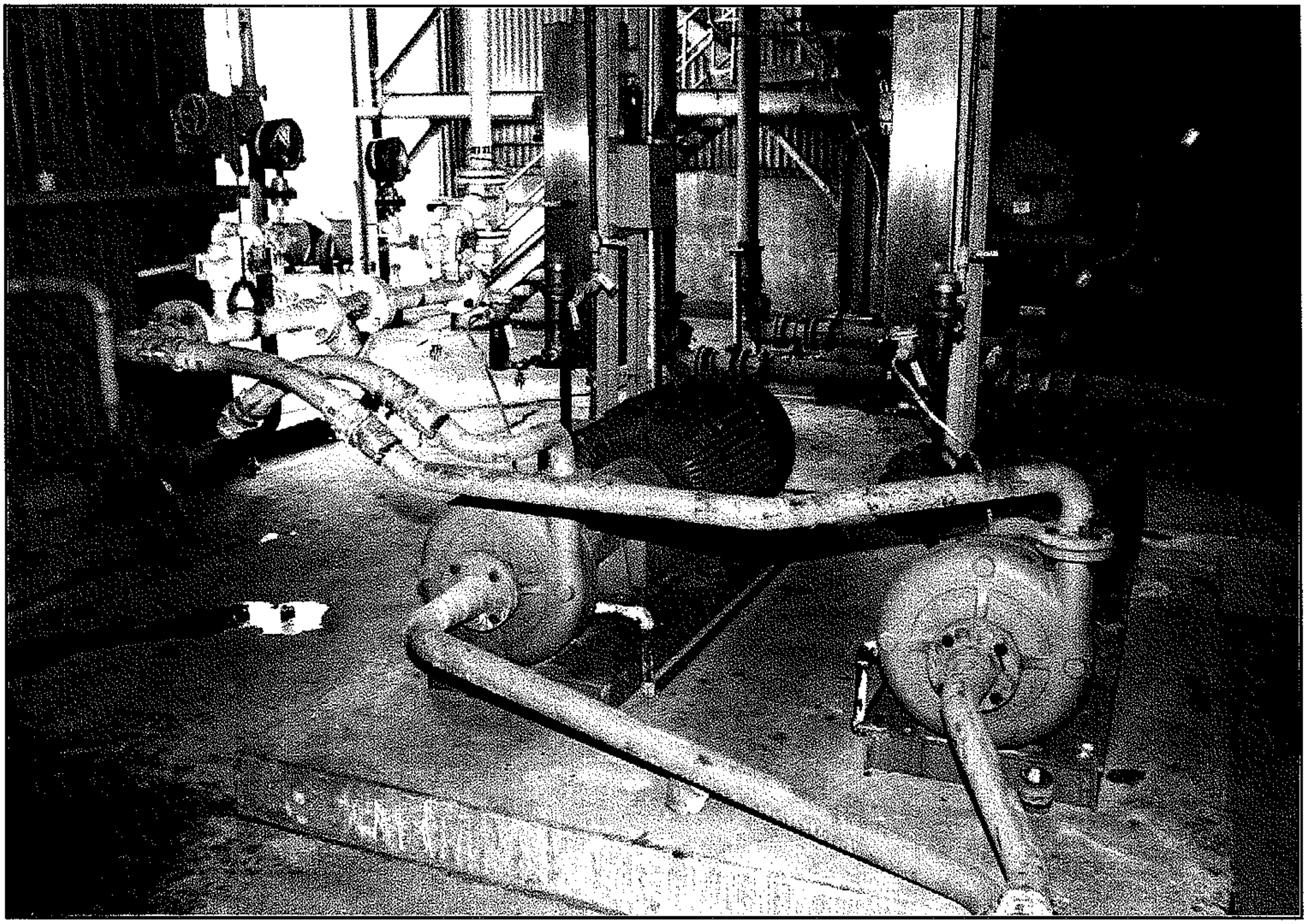


Figure 2-16
VIEW OF THE LIME SLURRY FEED AREA AT GRADE, VIEW 4

The major feature is the water booster pump.

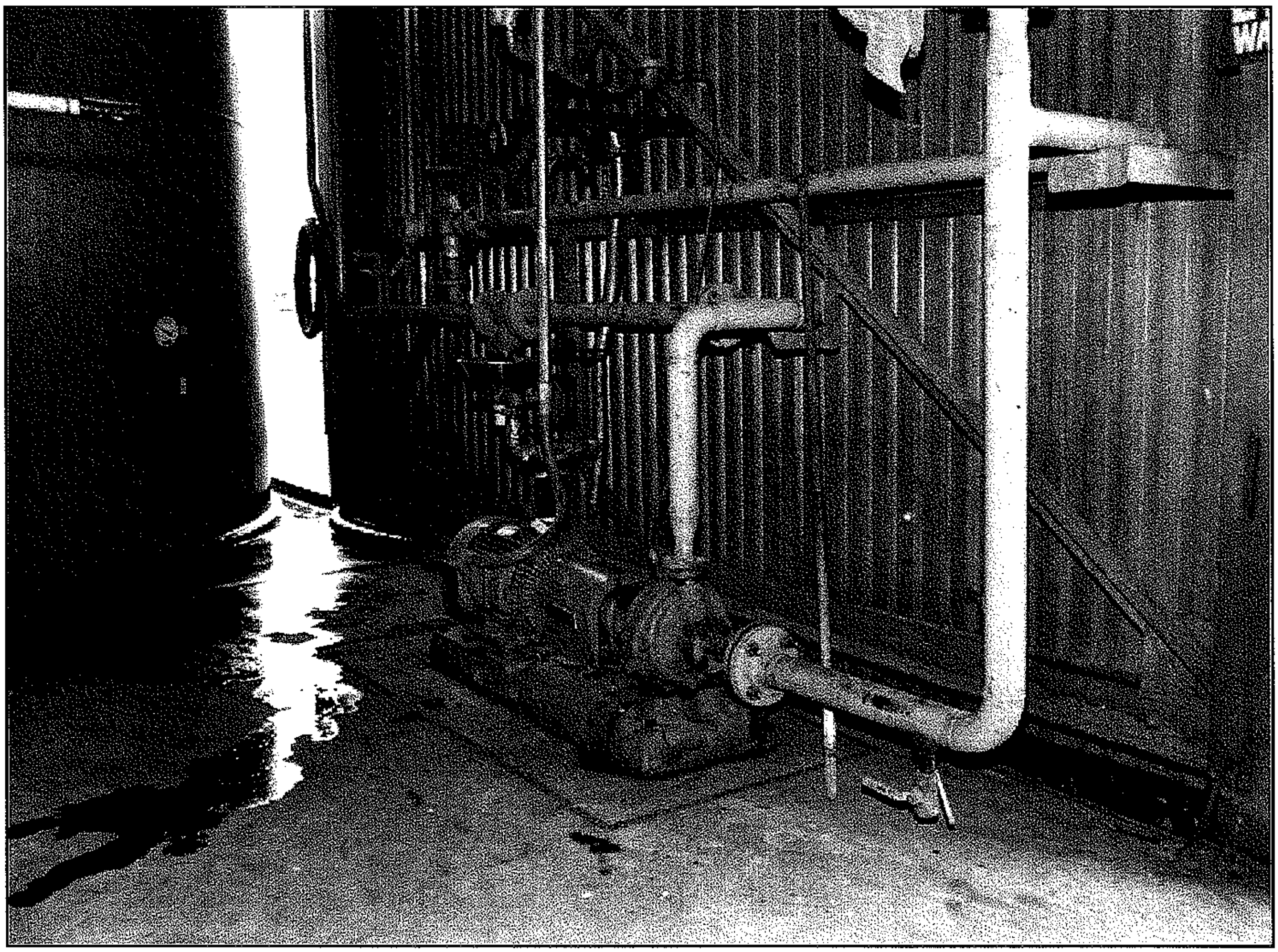


Figure 2-17
VIEW OF THE LIME SLURRY FEED AREA AT THE TOP OF THE FEED TANK, VIEW 1

Major features include a vibrating screen and an agitator.

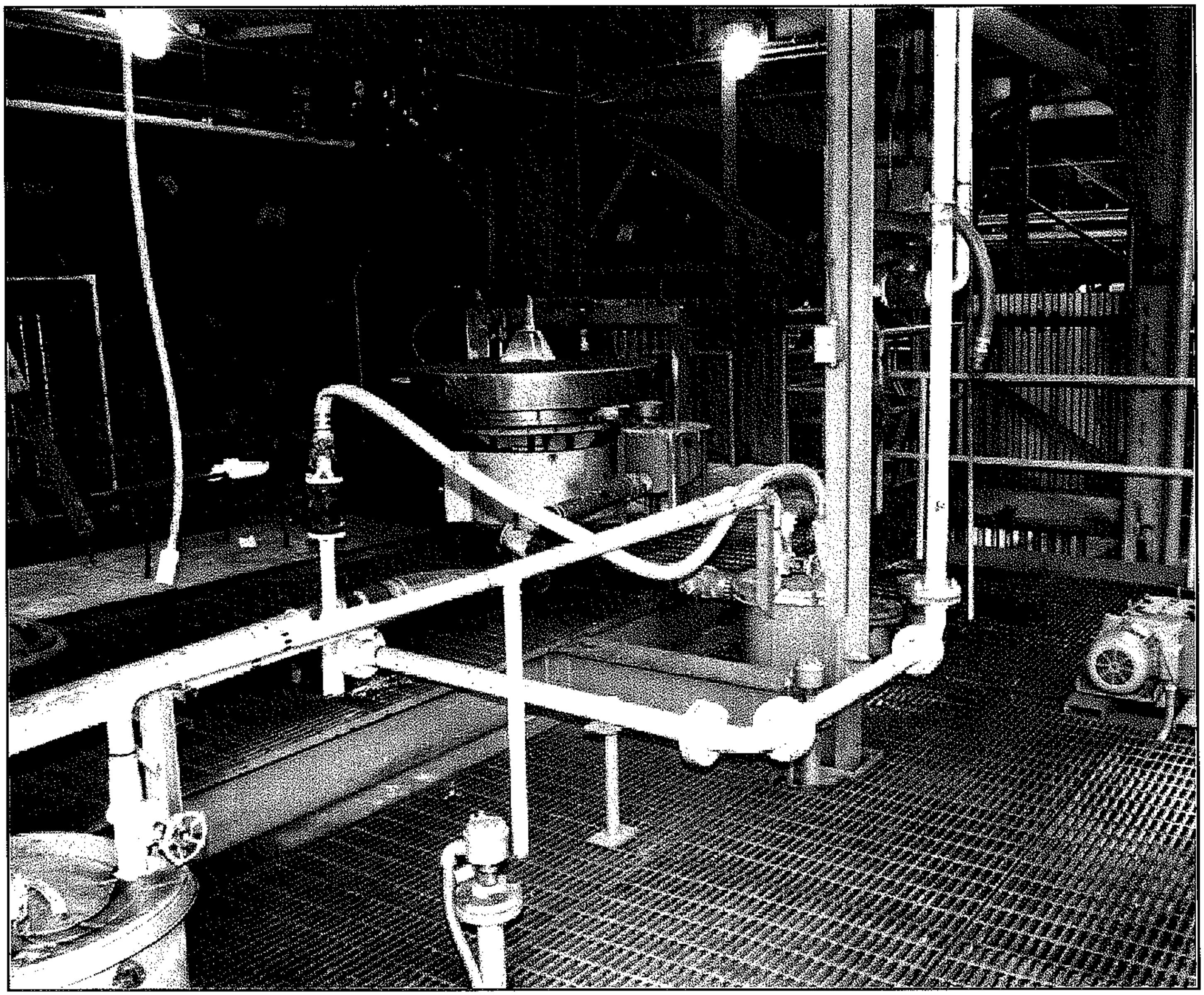


Figure 2-18
VIEW OF THE LIME SLURRY FEED AREA AT THE TOP OF THE FEED TANK, VIEW 2

Major features include a test stand at the far edge.

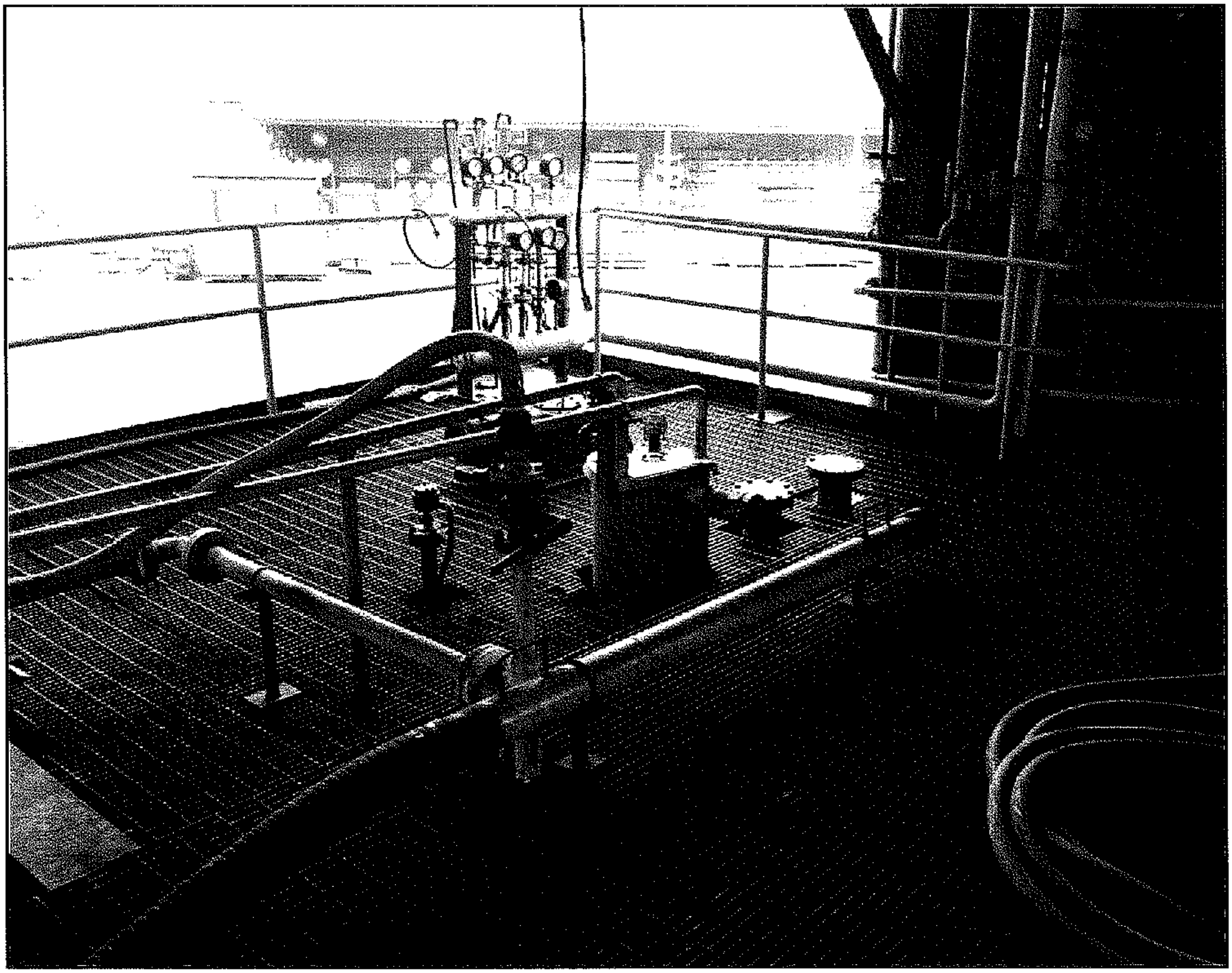


Figure 2-19
VIEW OF THE LIME SLURRY FEED AREA AT THE TOP OF THE FEED TANK, VIEW 3

Major features are the local MCC, which feeds the lime slurry feed and injection areas, and the steam valve for the soot blowers.

Figure 2-20
WEATHER ENCLOSURE FOR THE LIME SLURRY ATOMIZING SYSTEM

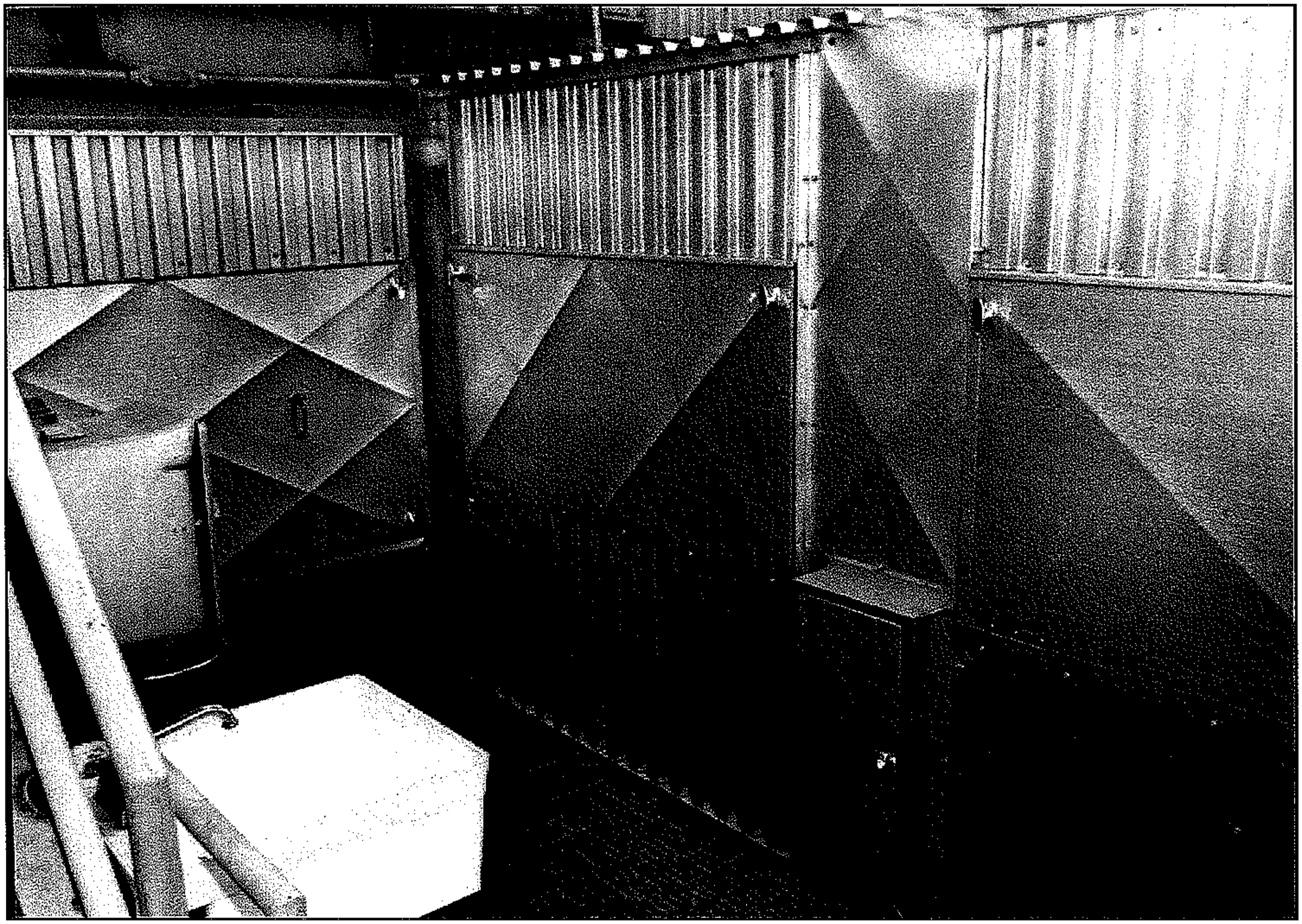


Figure 2-21
ATOMIZER LANCE MOUNTING PLATES WITH LIME SLURRY FEED AND ATOMIZING AIR LINES

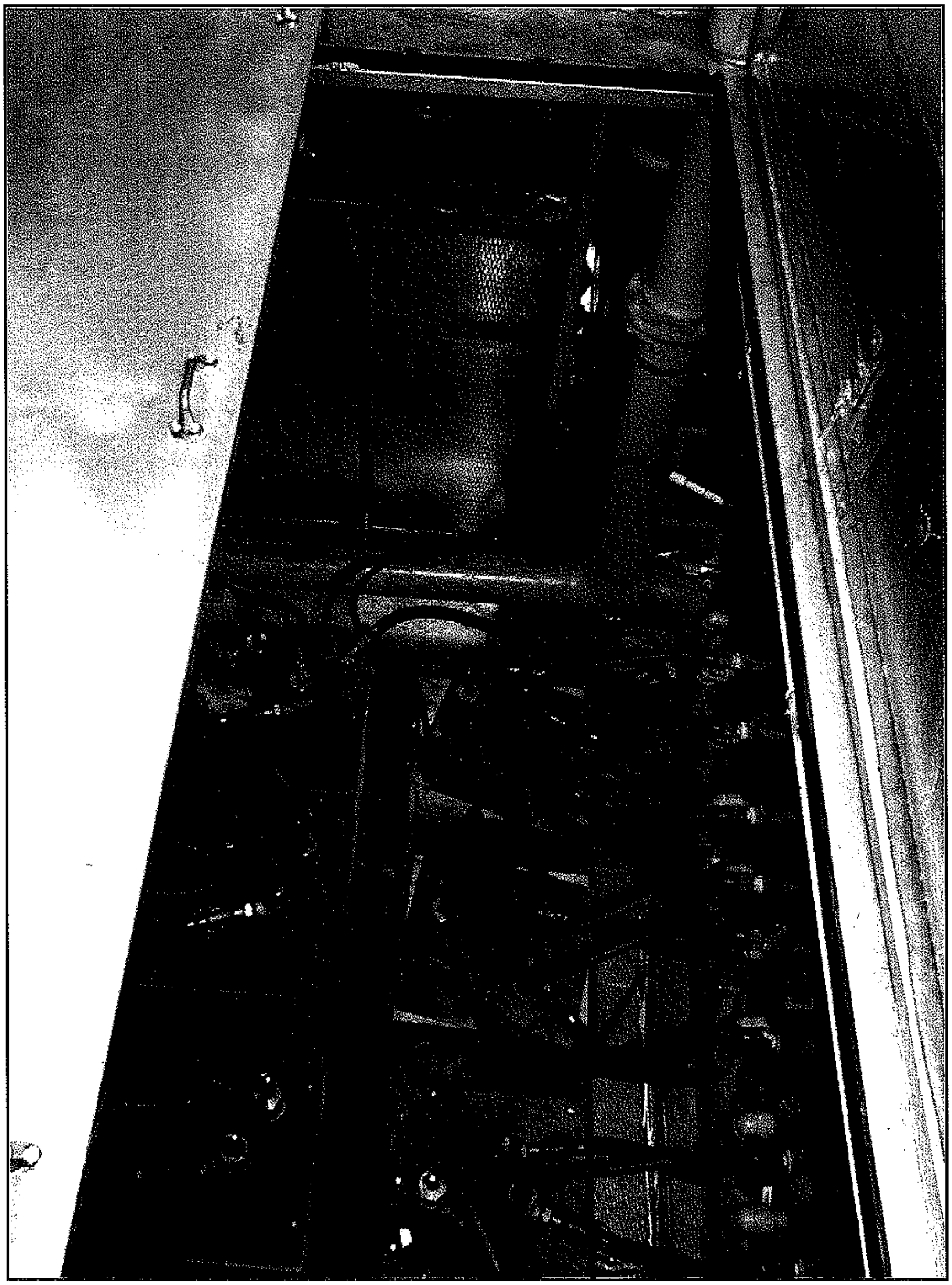


Figure 2-22
LIME SLURRY FEED HEADER AND ATOMIZING AIR HEADER

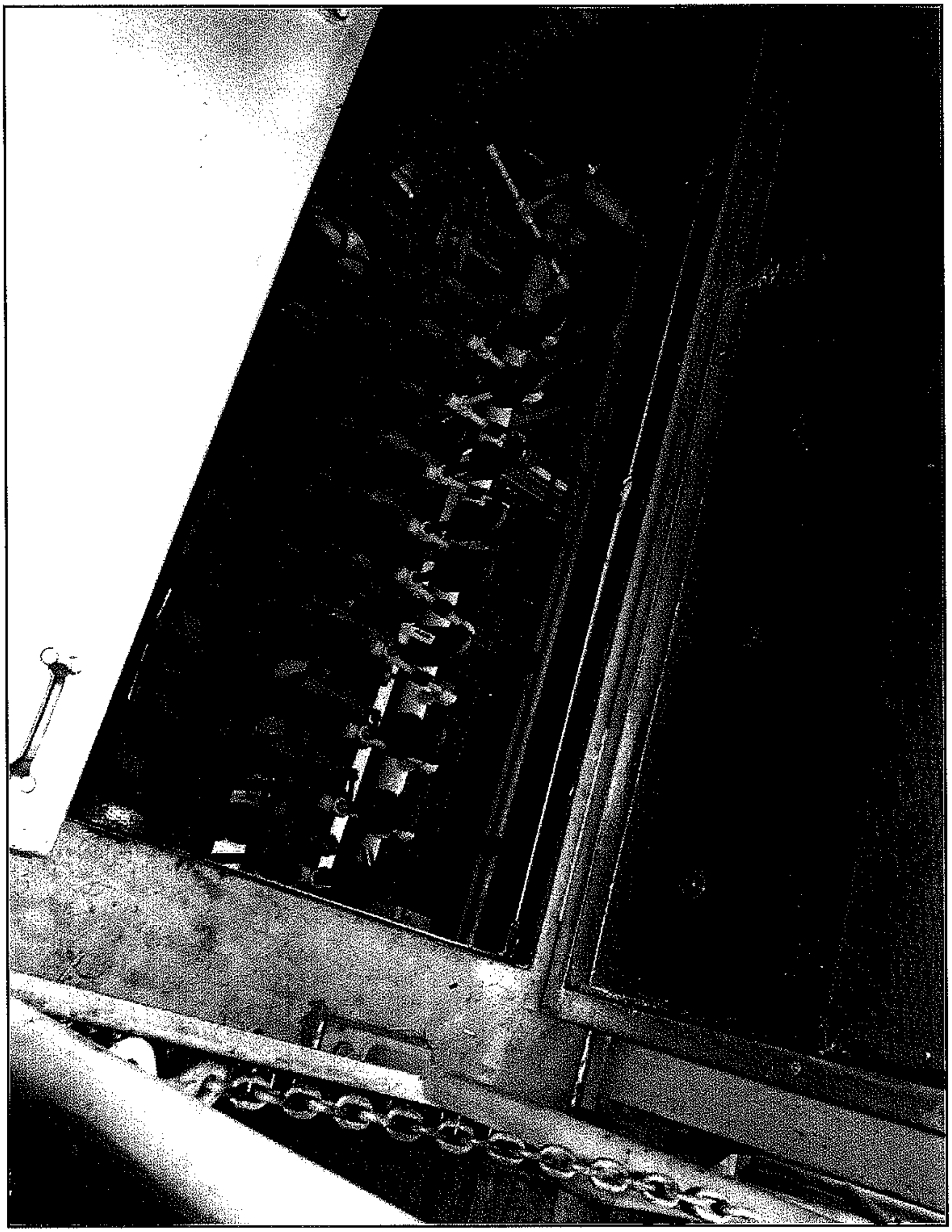


Figure 2-23
ACCESSIBILITY OF THE LIME SLURRY HEADER AND THE INSTRUMENTATION THROUGH ACCESS OPENINGS IN THE WEATHER ENCLOSURE

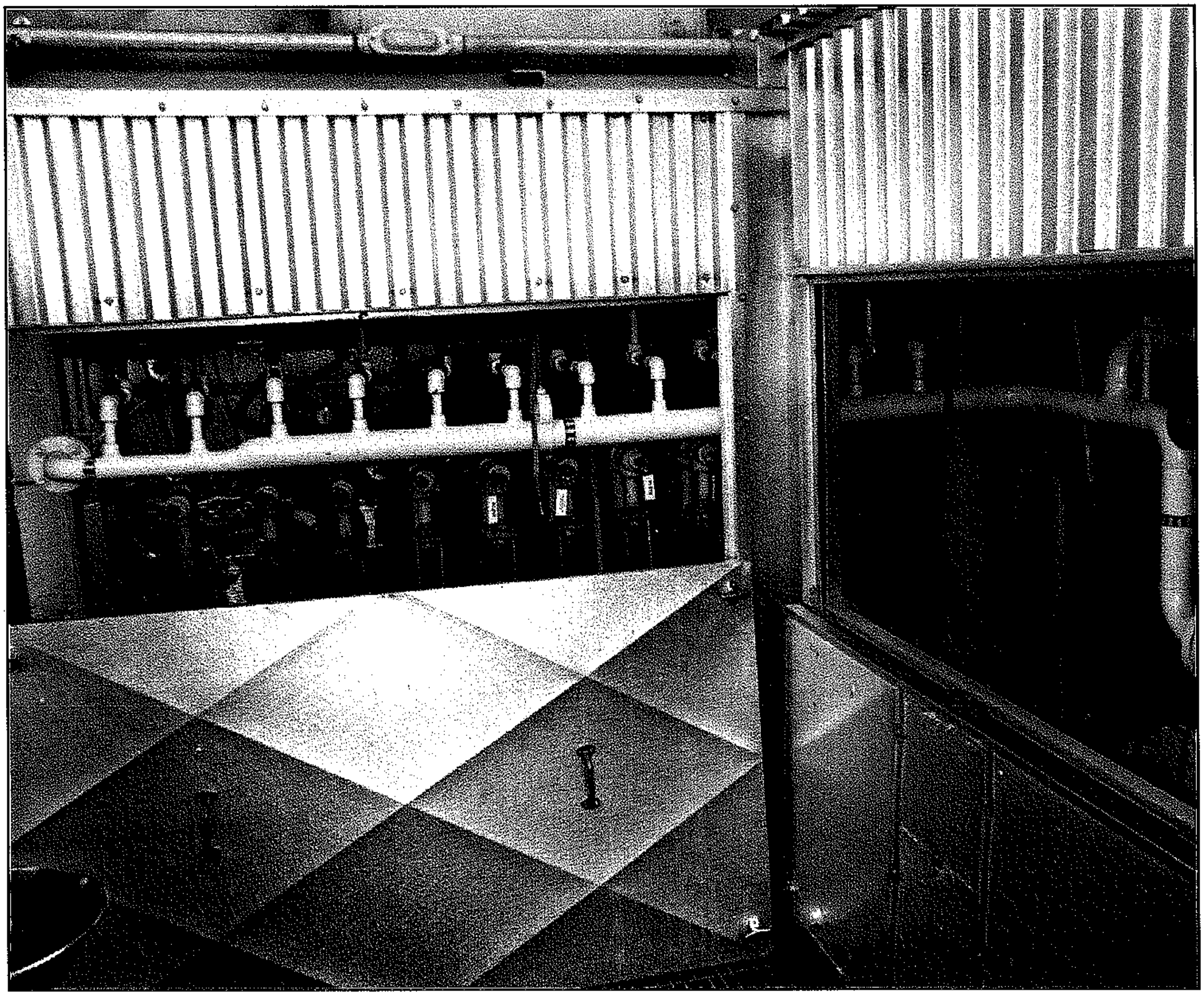


Figure 2-24
ACCESSIBILITY OF THE CONTROL VALVING AND THE INSTRUMENTATION THROUGH ACCESS OPENINGS IN THE WEATHER ENCLOSURE

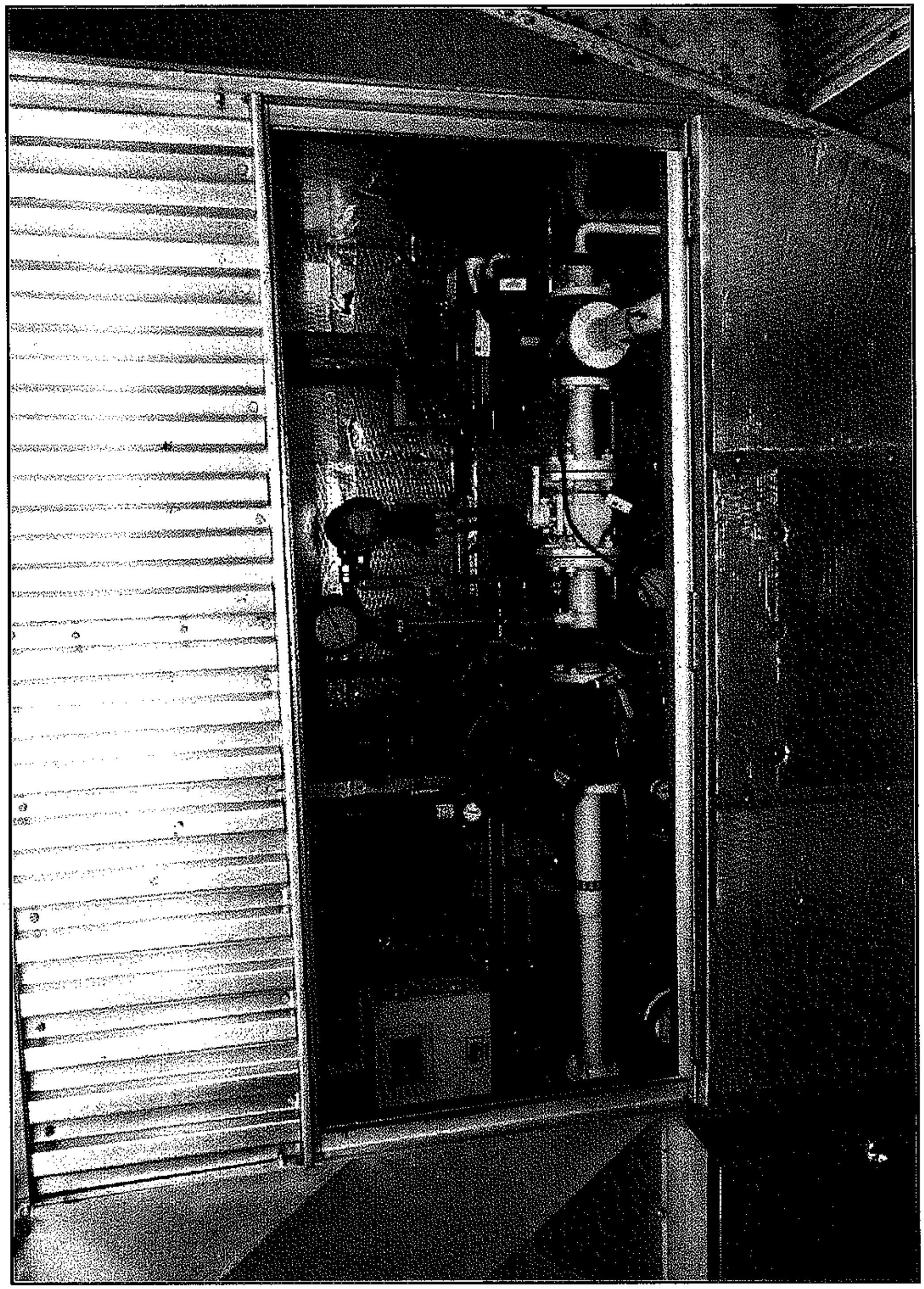


Figure 2-25
CZD DUCT EXTENSION

CZD duct extension with the existing duct (dull finish) shown at the left.

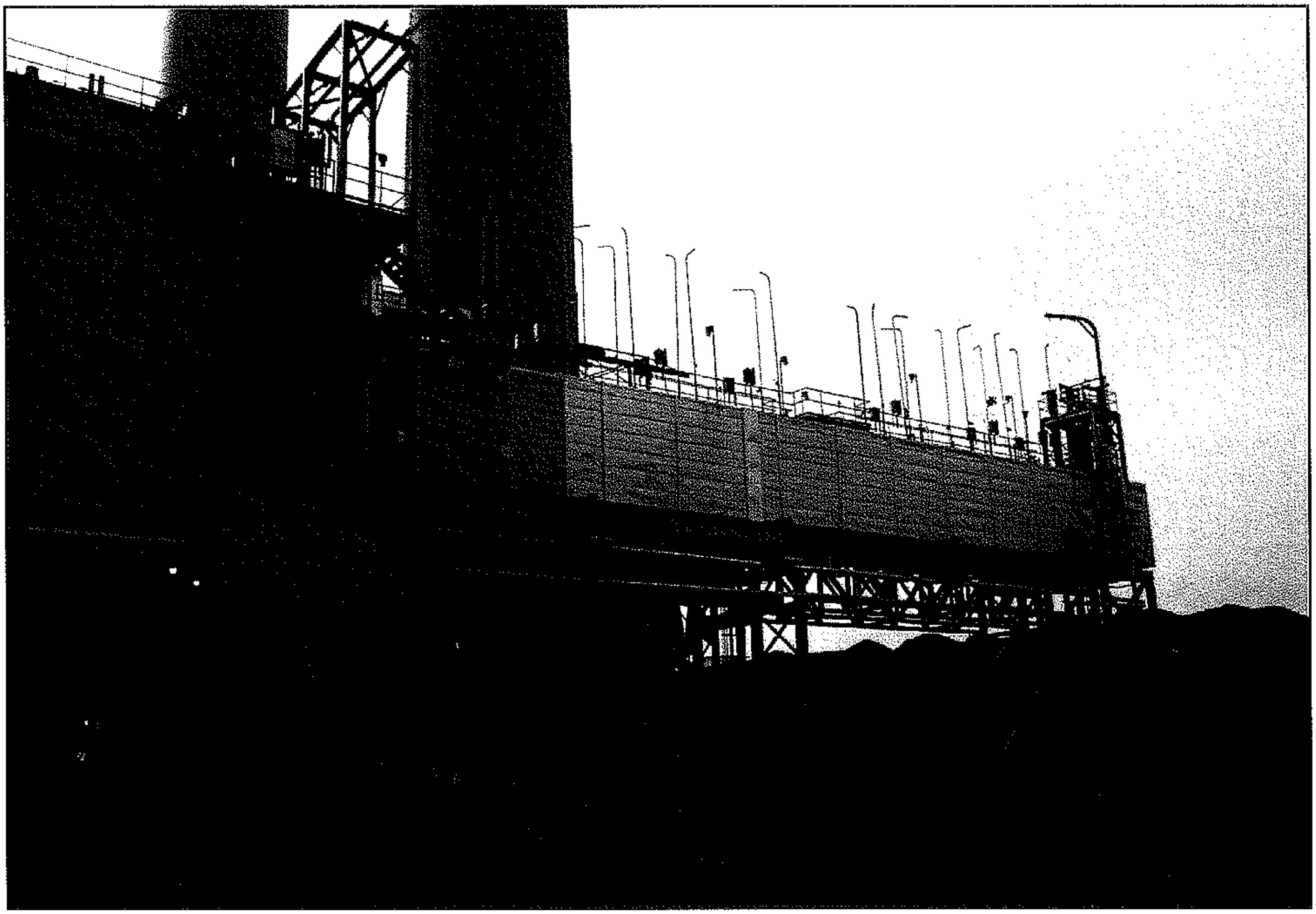


Figure 2-26
CZD DUCT EXTENSION, SOUTHERN END

CZD duct extension, southern end, with the retractable soot blowers/maintenance platform shown at the top.

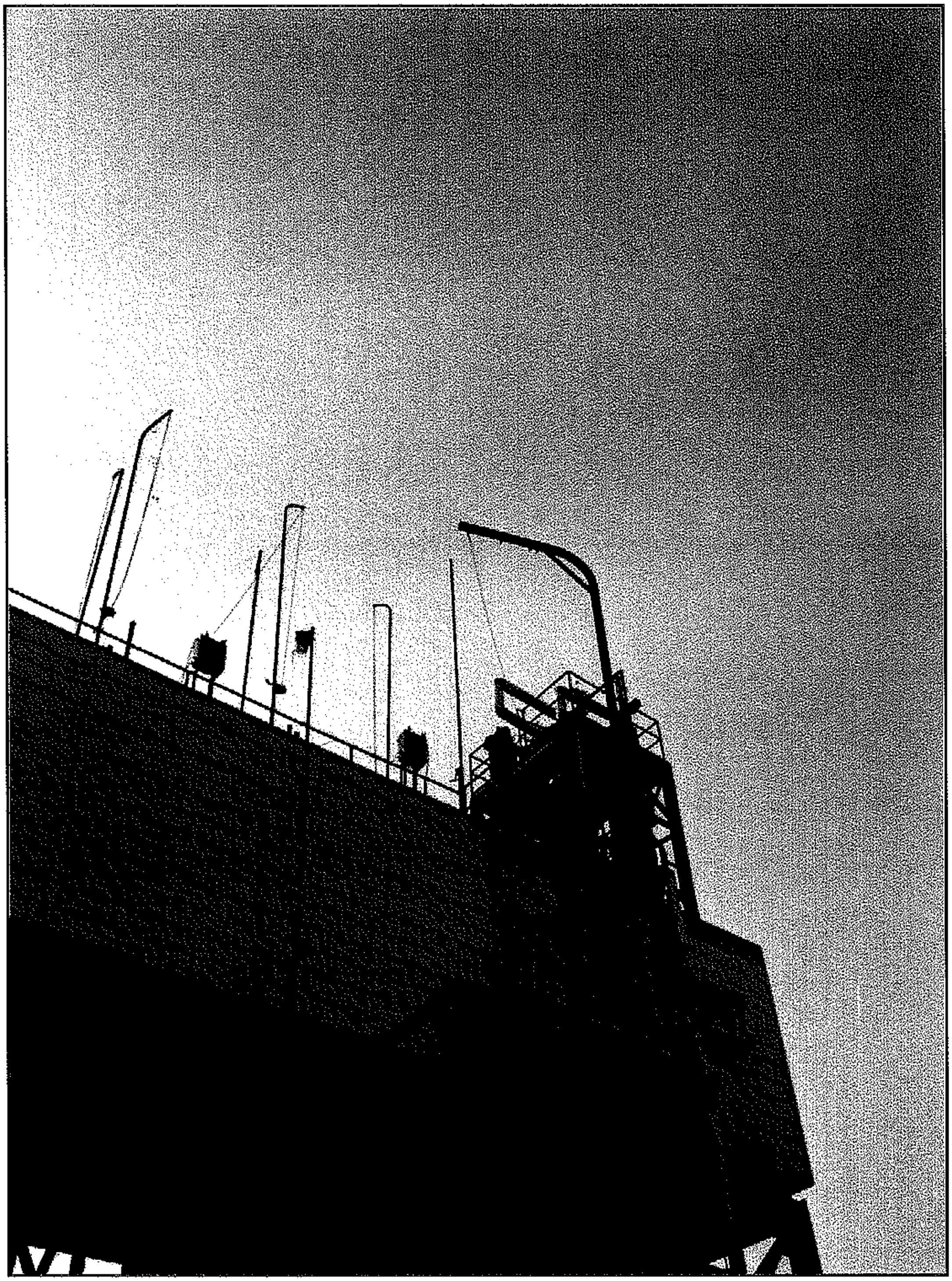


Figure 2-27
CZD DUCT EXTENSION AT THE PLANT END

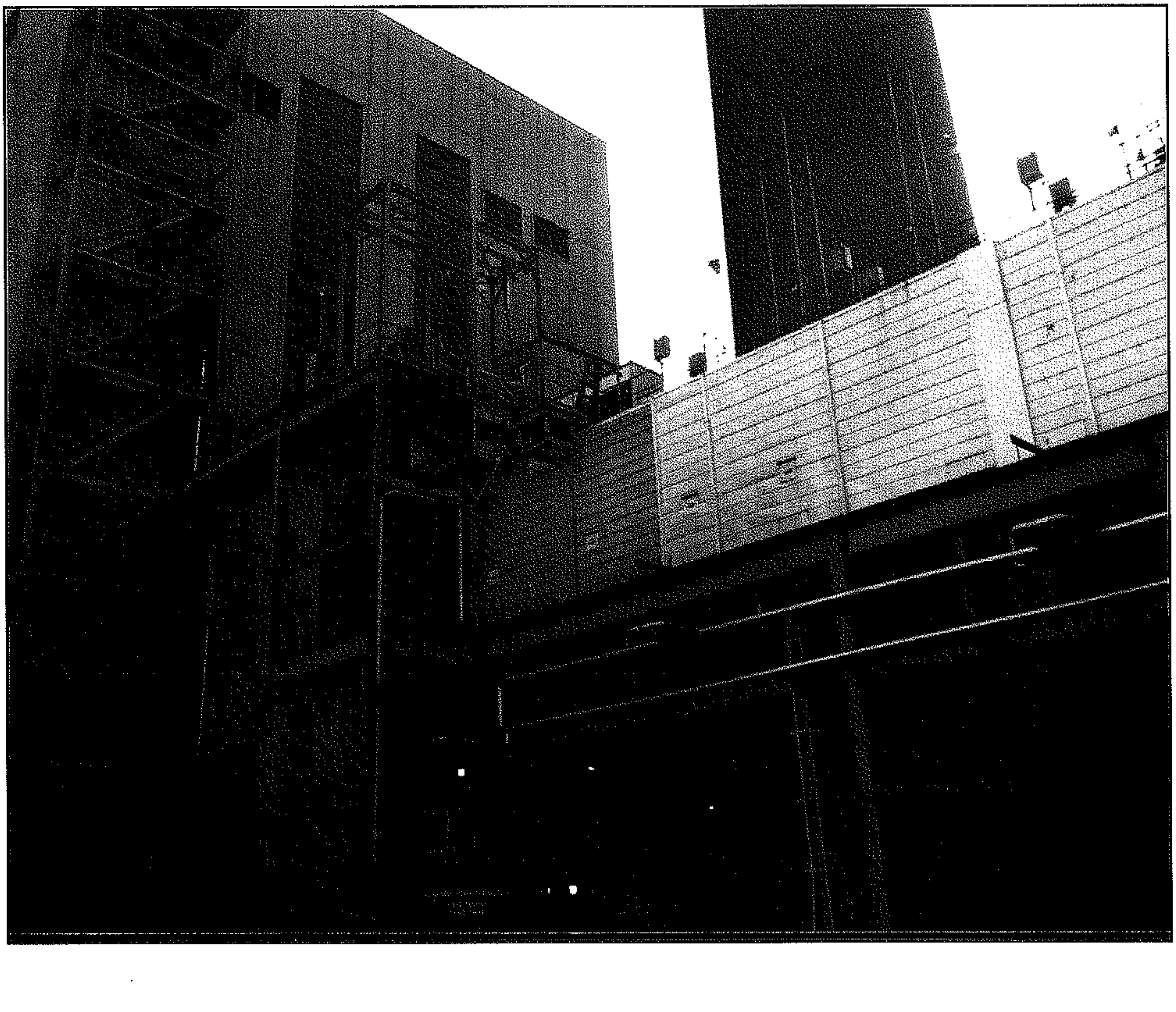


Figure 2-28
CZD DUCT EXTENSION, VIEW LOOKING SOUTH

Figure 2-29
CDZ DUCT EXTENSION, SOUTHEAST CORNER, WITH THE RETRACTABLE SOOT BLOWERS SHOWN IN THE SOUTHWEST CORNER

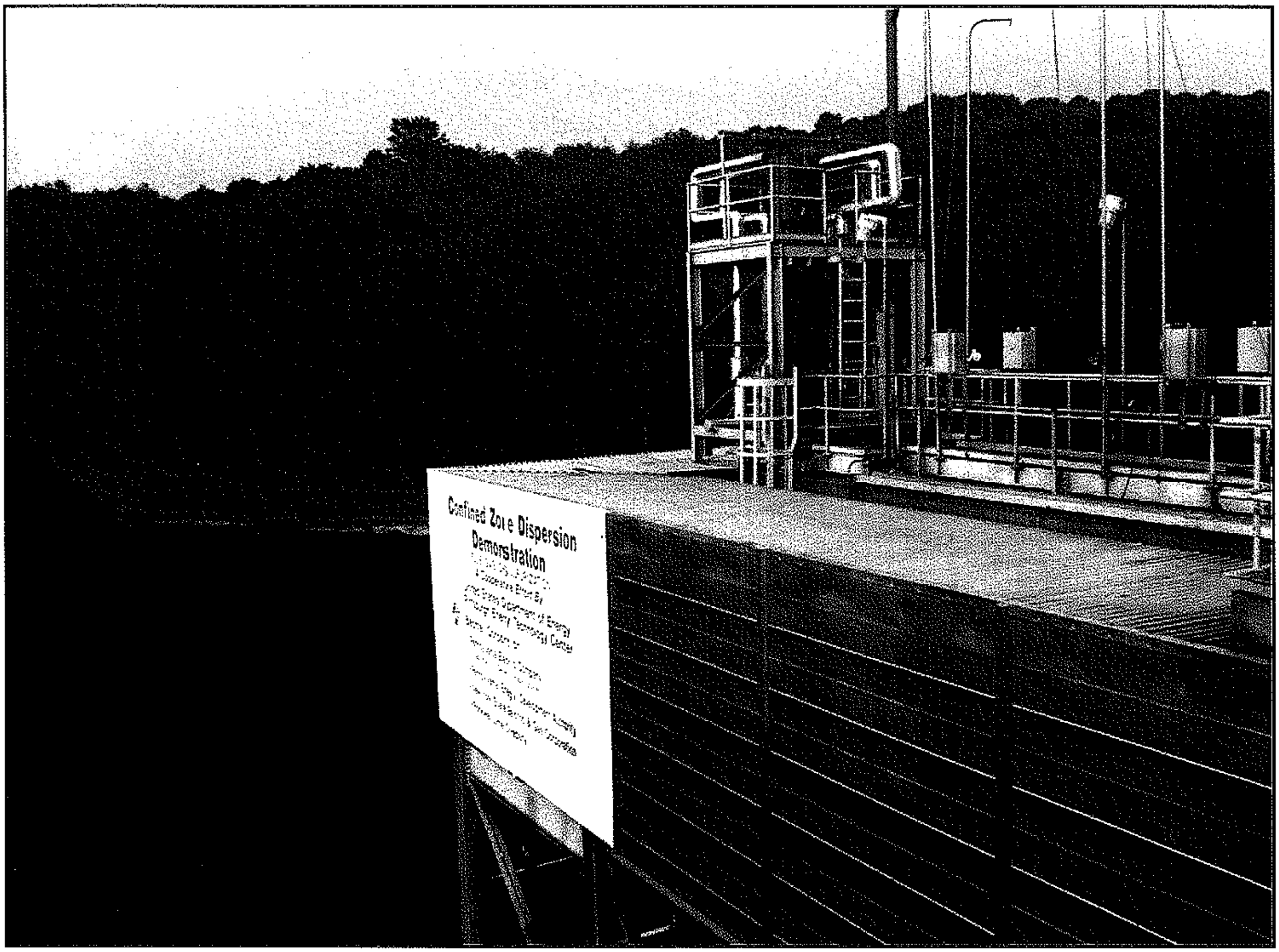


Figure 2-30
COPES-VULCAN ROTARY SOOT BLOWER, LOCATED IN THE BOTTOM OF THE DUCT

This installation is typical of RB-1 through RB-10.

Figure 2-31
COPES-VULCAN RETRACTABLE SOOT BLOWERS RB-11 THROUGH RB-14
(RB-11 ON THE LEFT)

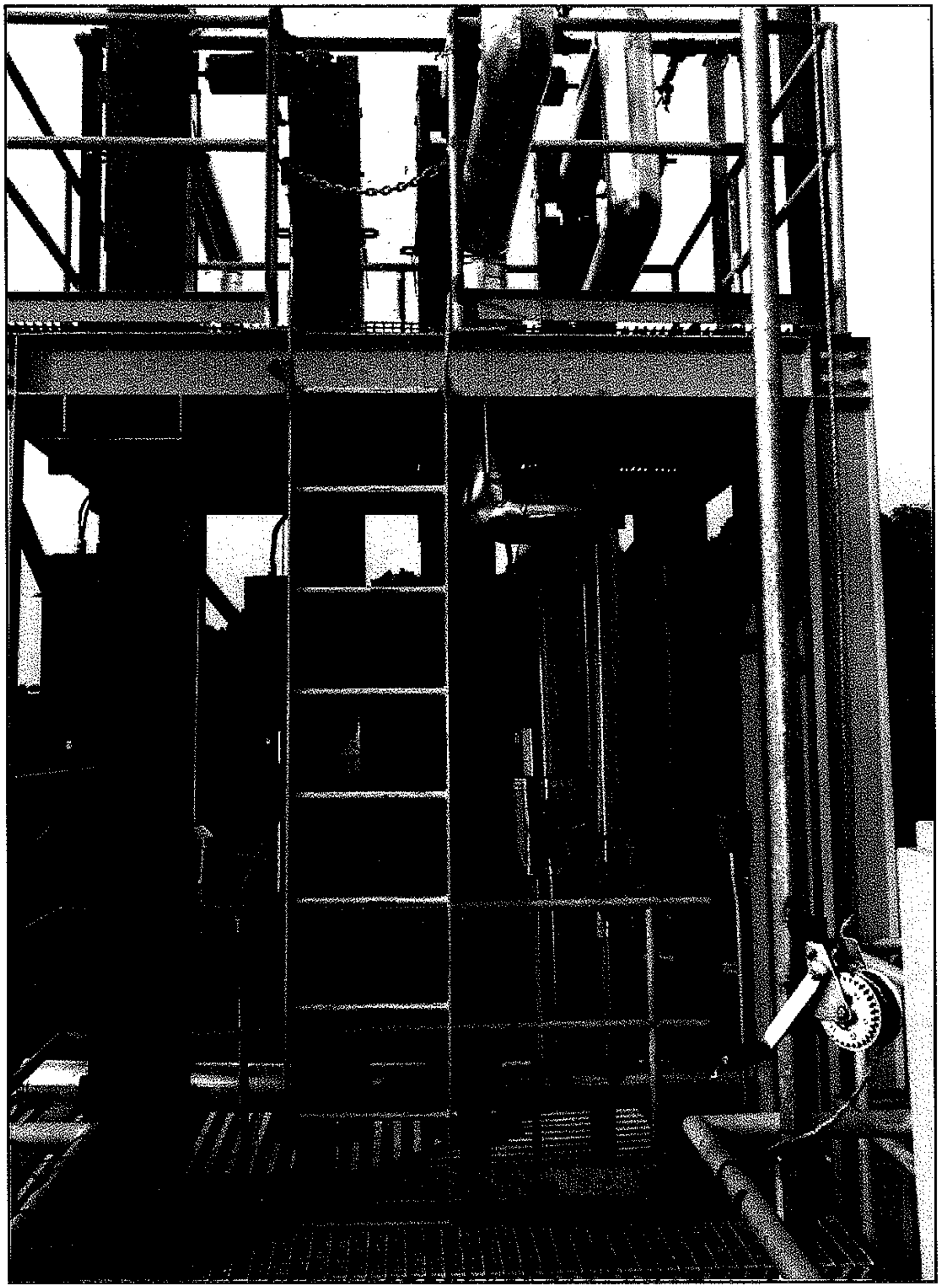


Figure 2-32
TURNING VANE THERMOCOUPLE JUNCTION BOXES, LOCATED AT THE BASE OF THE RETRACTABLE SOOT BLOWERS

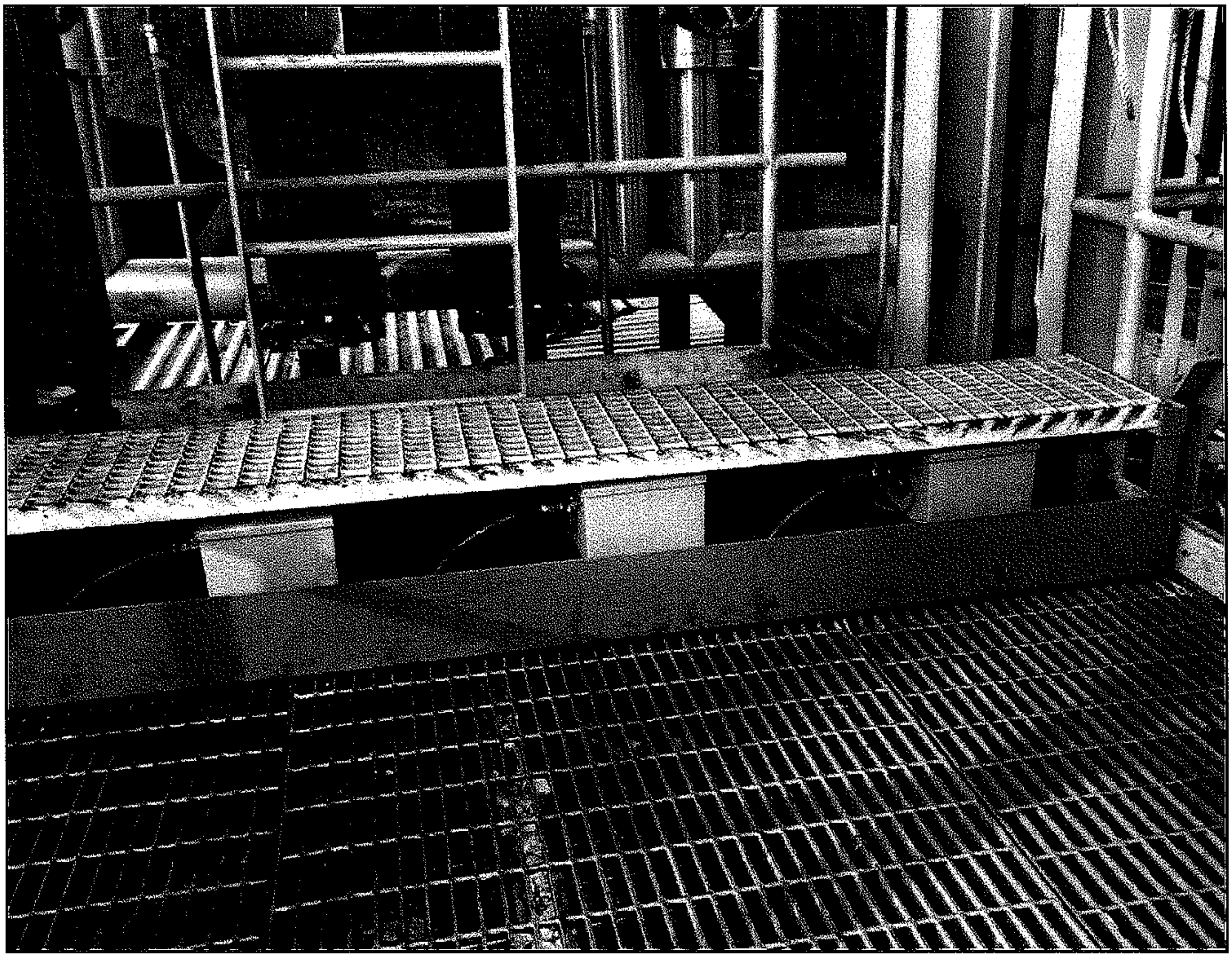
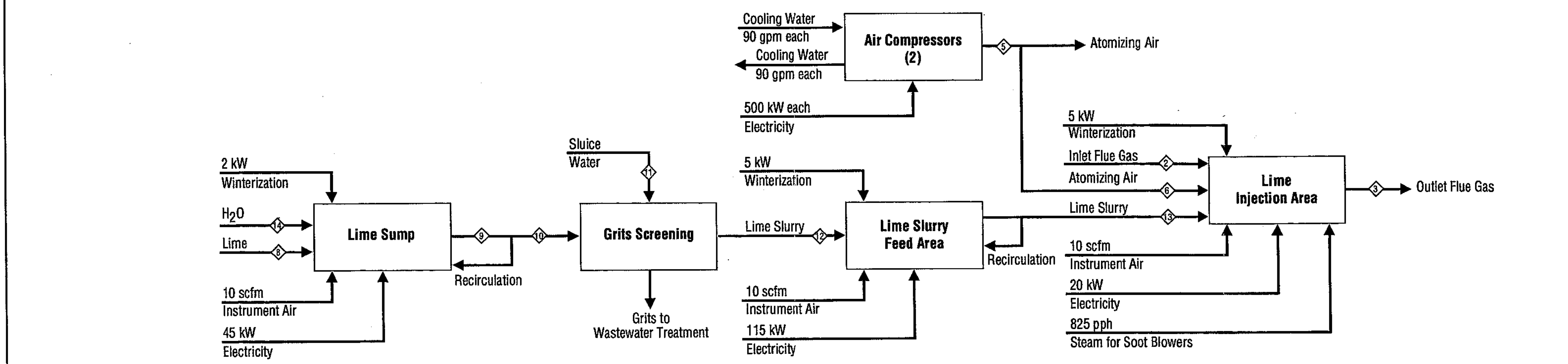


Figure 2-33
MATERIAL BALANCE AND ENERGY CONSUMPTION



Stream No.	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***
Stream Description	**Flue Gas at Inlet to 1st Stage ESP**	**Flue Gas at Outlet to 1st Stage ESP**	**Flue Gas at Inlet to 2nd Stage ESP**	**Flue Gas Discharge by I.D. Fan**	**Atomizing Air Supply Header**	**Atomizing Air Distribution Header**	**Atomizing Air to Single Atomizer**	**Lime Feed from Silo to Lime Sump**	**Lime Slurry Transfer Pump Discharge**	**Lime Slurry Feed to Vibrating Screen**	**Grits Sluicing Water**	**Degritted Lime Slurry Discharge to Lime Feed Tanks**	**Lime Slurry Distribution Header**	**Water to Lime Slurry Sump**
Components, lb/hr														
CO_2	138,006	138,006	138,006	138,006				–	–	–	–	–	–	–
N_2	627,620	627,620	633,884	633,884	6,364	2,030	112.76	–	–	–	–	–	–	–
O_2	74,298	74,298	76,201	76,201	1,903	616	34.24	–	–	–	–	–	–	–
H_2O	33,903	33,903	52,132	52,132	–	–	–	–	48,132	24,066	250	24,066	24,066	24,066
SO_2	1,624	1,624	812	812	–	–	–	–	–	–	–	–	–	–
NO_x	466	466	466	466	–	–	–	–	–	–	–	–	–	–
Particulate	6,460	1,704	4,504	34	–	–	–	–	–	–	–	–	–	–
Lime hydrate	–	–	–	–	–	–	–	2,093	4,185	2,093	–	2,093	2,093	–
Grits	–	–	–	–	–	–	–	99	197	99	–	49	49	–
Total	***882,377***	***877,621***	***906,005***	***901,535***	***8,267***	***2,646***	***147***	***2,192***	***52,514***	***26,258***	***250***	***26,208***	***26,208***	***24,066***
Properties														
Temperature, °F	290	290	196.3	196.3	108	108	108	60	60	60	60	60	60	60
Pressure, in. H_2O	-6	-10	-11	0	125 psig	105 psig	100 psig	–	104.6	104.6	60–100	Atmos.	140	50–100
Flow, acfm	265,497	288,469	263,988	248,072	205.9	81	4.5	–	–	–	–	–	–	–
Flow, gpm	–	–	–	–	–	–	–	–	100	50	0.5	50	50	48
Mol. wt.	29.4	29.4	–	29.0	28.84	28.84	28.84	–	–	–	–	–	–	–
O_2 conc., vol% (wet)	7.8	7.8	7.66	7.66	21.0	21.0	21.0	–	–	–	–	–	–	–
H_2O vap. conc., vol% (wet)	6.3	6.3	9.32	9.32	–	–	–	–	–	–	–	–	–	–
SO_2 conc., ppm (wet)	852	852	409	409	–	–	–	–	–	–	–	–	–	–
NO_x conc., ppm (wet)	340	340	325	325	–	–	–	–	–	–	–	–	–	–
Particulates, gr/scf (dry)	4.296	1.126	2.948	0.022	–	–	–	–	–	–	–	–	–	–
Concentration, wt% (solids)	–	–	–	–	–	–	–	100	8.0	8.0	0	8%	8%	0
Density, lb/ft^3	0.0511	0.0506	0.0569	0.0605	0.661	0.566	0.543	30 bulk	64.8	64.8	62.34	64.8	64.8	62.34
Viscosity, cp	0.0225	0.0225	0.0205	–	0.0185	0.0185	0.0185	–	8.12	8.12	1	8.12	8.12	–

93-0451b.005 tg/ms:2 8-5-93

Figure 2-34
SURFACE DRAINAGE SYSTEM AT SEWARD STATION

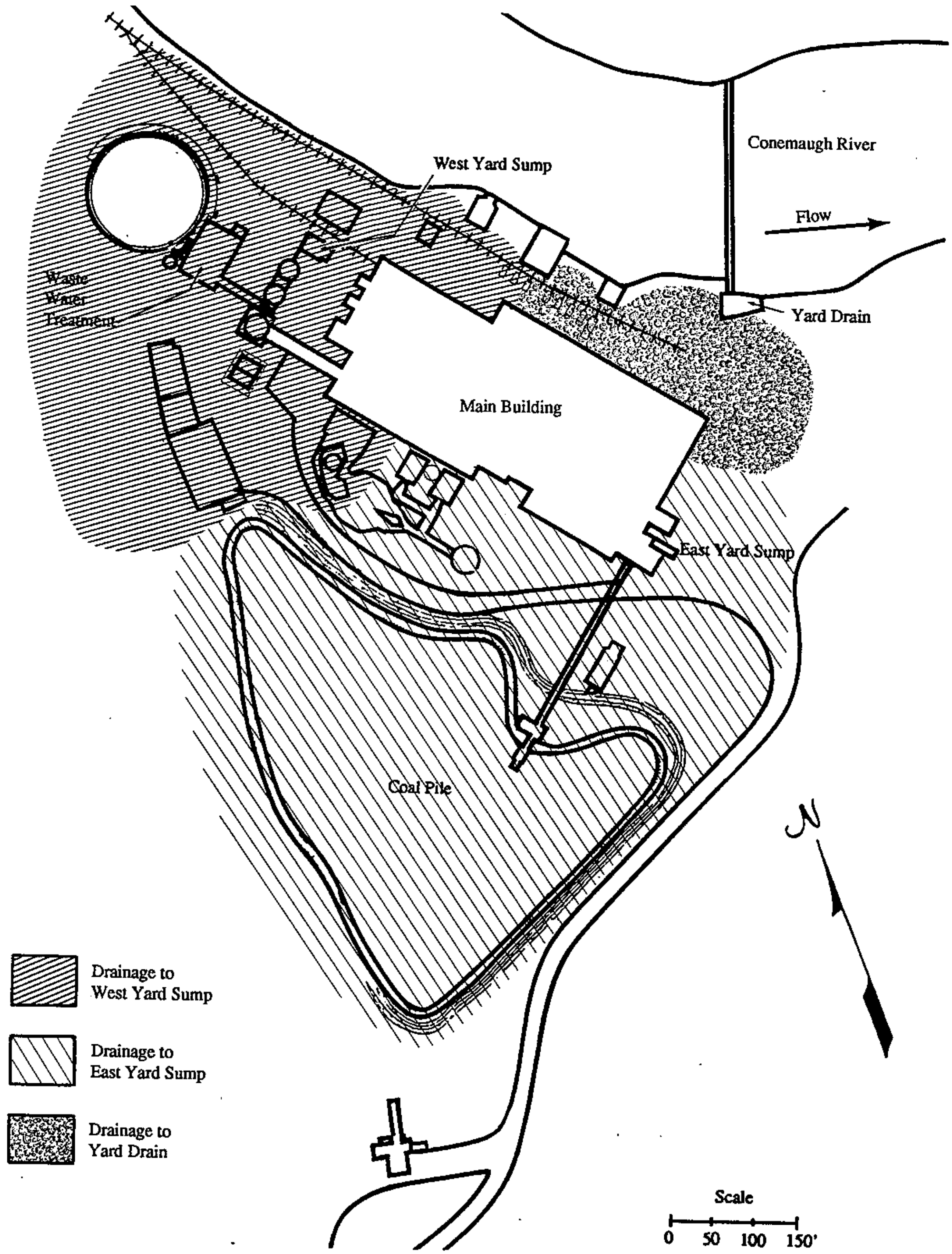


Figure 2-35
OUTFALLS TO THE CONEMAUGH RIVER

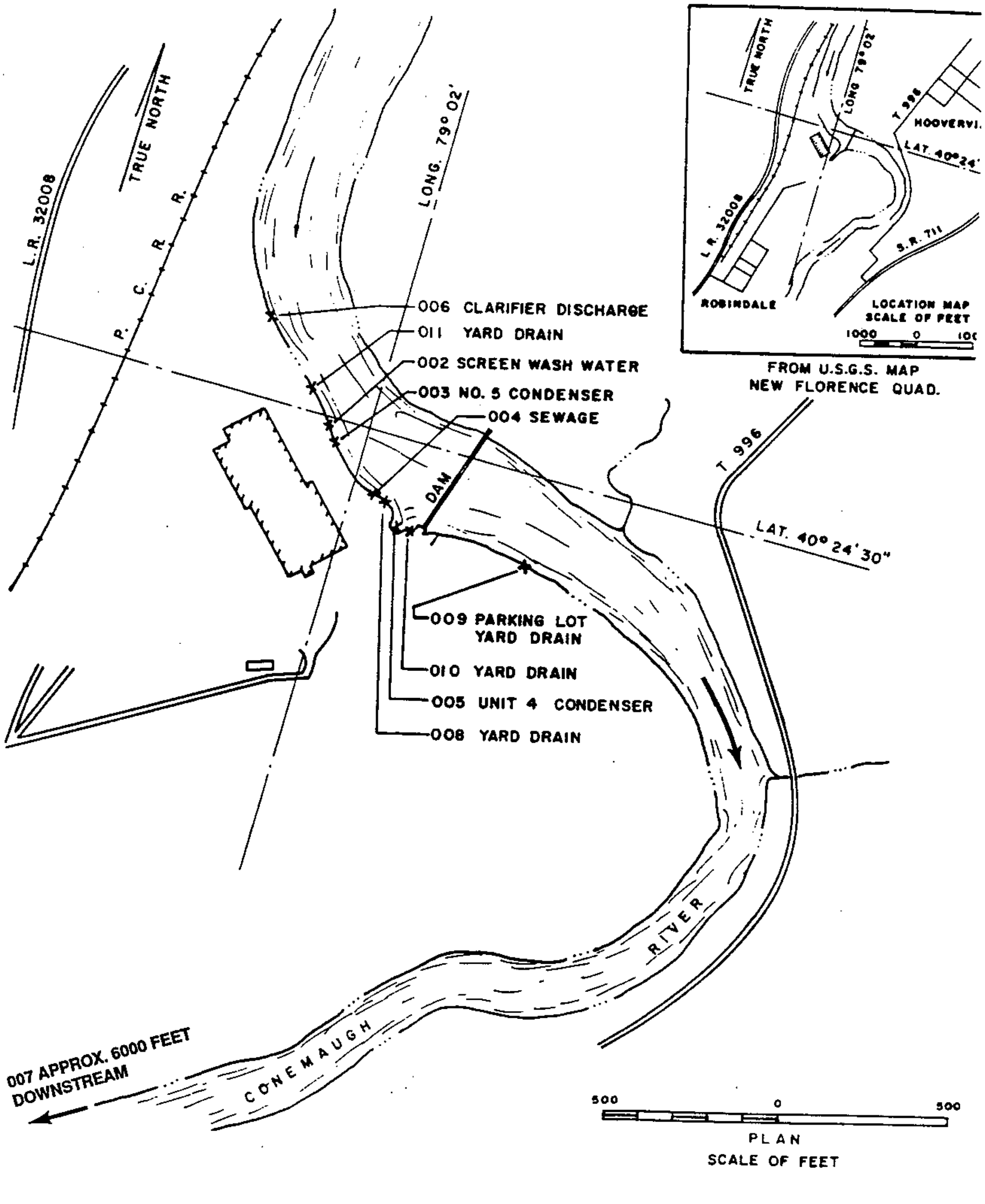


Table 2-1
SOURCES, OUTFALLS, AND DISCHARGE RATES

Outfall Number	Source	Representative Monthly Discharge Rate (a)
002	Screen wash water	(b)
003	Unit 5 condenser cooling water	124.0 mgd
004	Sewage treatment plant	0.00341 mgd
005	Unit 4 condenser cooling water	58.9 mgd
006	Clarifier discharge	0.015 mgd
007	Yard drain	Intermittent, during/after rainfall
008	Yard drain	Intermittent, during/after rainfall
009	Paved parking lot yard drain	Intermittent, during/after rainfall
010	Paved yard area drain	Intermittent, during/after rainfall
011	Yard drain	Intermittent, during/after rainfall

(a) All discharges are within NPDES permit provisions.

(b) A representative monthly discharge rate is not available for screen wash water. The screen wash pumps, rated at 680 gpm, operate intermittently, depending on the quantity of material (floating trash, leaves, etc.) obstructing the flow of water through them. Screen wash water quantities are usually highest in the autumn, when fallen leaves are abundant in the river.

3.0

Plant Process Data

3.0 PLANT PROCESS DATA

This section of the design report presents plant process information, including:

- The design basis for the CZD system
- Descriptions of the plant equipment, along with associated process utility requirements
- Important operational features of each process area
- Detailed equipment lists
- Drawings lists identifying pertinent drawings located in Appendix C

In addition, it discusses the plant winterization techniques used to protect the plant during freezing weather, and describes the components and operation of the instrument and control system.

3.1 CZD PROJECT DESIGN BASIS

This section presents the design basis for the CZD system at Seward Station. The system was designed to remove 50 percent of the SO_2 from one-half of Boiler 15's flue gas. The section contains:

- Coal properties used to estimate flue gas properties
- Boiler characteristics such as:
  - Heat rate
  - Capacity/load
  - Type
- Flue gas properties, including:
  - Composition
  - Molecular weight
  - Flow
  - Flue gas velocity
- Process requirements, such as:
  - SO_2 removal
  - Lime utilization
  - Lime usage
  - Water requirement
  - Waste disposal requirements
  - Power usage

- Bases for sizing the test duct
- Site conditions such as the elevation above sea level, barometric pressure, and ambient temperatures
- Test program requirements

3.1.1 Coal Properties

The coal properties used to estimate flue gas properties are as follows:

Table 3-1
COAL COMPOSITION
(Typical for Estimating Flue Gas Properties)

Component	Concentration	
	Wet wt%	Dry wt%
C	73.16	67.75
H	4.09	3.79
N	1.24	1.15
S	1.576	1.46
O	4.254	3.94
H_2O	—	7.39
Ash	15.68	14.52
Total	100	100.00

The high heating value is 11,958 to 12,200 Btu/lb.

3.1.2 Boiler Characteristics

The boiler has the following characteristics:

- Heat rate: 9,500 Btu/kWh
- Capacity: 140 to 150 MW
- Type: Balanced draft

During initial testing of the CZD system at Seward Station in 1987, the maximum boiler load was 140 MW. Therefore, this value was used to estimate flue gas properties.

3.1.3 Flue Gas Properties

The flue gas properties are shown in Table 3-2.

Table 3-2
FLUE GAS PROPERTIES
(Flows, expressed in lb mol/hr and lb/hr, correspond to one-half of total flow)

Composition	Concentration vol %	Lb Mol/Hr	Lb/Hr
CO_2	10.53	3,136.5	138,006
N_2	75.24	22,415.0	627,620
O_2	7.79	2,321.8	74,298
H_2O	6.32	1,883.5	33,903
SO_2	852 ppm	25.37	1,624
NO_x	339 ppm	10.10	466
Total	100.00	29,792.27	875,917

The O_2 content of the flue gas is based on gas analysis of the test boiler, as follows:

- The molecular weight of flue gas is 29.4
- The flue gas temperature at the inlet to the test duct is 300°F
- The flue gas flow = 875,917 lb/hr
  = 188,436 scfm
  = 284,903 acfm at 29 in. Hg and a temperature of 300°F
- The duct cross-section area is 88 ft^2
- The flue gas velocity at the inlet to the test duct is 54 fps

3.1.4 Process Requirements

The process requirements are as follows:

- SO_2 removal = 50 percent
  - Lime utilization = 40 percent (assumed)
    - with calcitic lime = 2,444 lb/hr, based on 96 percent purity
    - with dolomitic lime = 2,217 lb/hr, based on the following composition:

$Mg(OH)_2$ = 37.5 wt%	0.6466	lb mol/100 lb of lime
$Ca(OH)_2$ = 58.0 wt%	0.7838	lb mol/100 lb of lime
Grits = 4.5 wt%	______	
	1.4304	lb mol/100 lb of lime

- Water requirement = 60 gpm (55 gpm in slurry and 5 gpm utility uses)
- Process waste disposal requirements:
  - From calcitic lime:

Components	*lb mol/hr*	*lb/hr*
$CaSO_4 \cdot 2H_2O$	6.343	1,091.0
$CaSO_3 \cdot {}^1/_2H_2O$	6.342	818.1
$Ca(OH)_2$	19.028	1,408.0
Grits		99.8
Total		3,414.9

  - From dolomitic lime:

Components	*lb mol/hr*	*lb/hr*
$CaSO_4 \cdot 2H_2O$	6.343	1,091.0
$CaSO_3 \cdot {}^1/_2H_2O$	6.342	818.1
$Ca(OH)_2$	4.692	317.2
$Mg(OH)_2$	14.335	831.5
Grits	–	95.3
Total		3,153.1

3.1.5 Power Usage

The power usage of the major CZD system components is listed in Table 3-3.

Table 3-3
POWER USAGE

Item	Motor (hp)	kW
Atomizing Air Compressor	500	414.5
Lime Slurry Transfer Pump	30	24.9
Lime Slurry Feed Pump	100	82.9
Lime Slurry Feed Tank Agitator	5	4.1
Grits Tank Agitator	3	2.5
Lime Sump Agitator	15	12.4
Water Booster Pump	15	12.4
Lime Silo	10	8.3
Grits Screen	5	4.1
Miscellaneous	10	8.3
Total	693	574.4

$$\text{Electric power requirement} = \frac{693 \times 0.746}{0.9}$$

$$= 574.4 \text{ kW}$$

$$\text{Winterization} = 10.0 \text{ kW}$$

$$\text{Lighting} = \underline{2.0} \text{ kW}$$

$$\text{TOTAL} = \underline{\underline{586.4}} \text{ kW}$$

The sootblowing steam requirements are as follows:

- 150 psi steam requirements for operation of rotary floor sootblowers:
  = 1,425 lb/hr for 0.67 minutes per each of 10 sootblowers
  = 955 lb/24 hrs/day when each sootblower is activated every 4 hours.

- 150 psi steam requirements to operate the retractable sootblowers that keep the turning vanes in section C clean:
  = 4,400 lb/hr for 2.5 minutes per each of 4 sootblowers
  = 4,400 lb/24 hours/day when each sootblower is activated every 4 hours

Therefore, the total daily steam usage is 5,355 lbs.

3.1.6 New Test Duct Requirements

To remove 50 percent of the SO_2 from the flue gas, it is necessary to inject about 50 to 55 gpm of lime slurry containing 7-10 wt% of lime.

Experience gained from operation of the Campbell CZD-POC project where a 120-foot-long duct permitted more than a 50 percent SO_2 removal – and from the 1987 operation of the Seward CZD system where a 35-foot-long duct with a 0.75-second holdup time did not permit more than 15 to 20 percent SO_2 removal – indicates that a 2-second flue gas holdup time is required for 50 percent SO_2 removal at Seward Station. The 2-second flue gas holdup time corresponds to the effect created by the 120-foot-long, straight-section duct.

The Seward boiler is a balanced draft boiler, and its flue gas test duct operates under a vacuum of an 11" to 6" water column, permitting a change of atomizers and temperature probes during normal boiler operation without flue gas leakage from the duct.

3.1.7 Site Conditions

See p 2-3.
Design Cond 14.7 psia & 60°F

The conditions at the CZD site are as follows:

- Elevation: 1,085 feet above sea level
- Barometric pressure range: 28" to 30" Hg
- Ambient temperature range: 20°F in winter to 100°F in summer

3.1.8 Test Program Requirements

The test program will consist of 6 months of parametric testing and 12 months of continuous operation. For parametric tests, the system will be operated manually using local indicators. For continuous operation, the system will be provided with spare pumps and additional instrumentation so that it can be operated automatically from the power plant control room.

Parametric testing will be an exploratory program. Its objectives will be to:

- Find the best configuration of atomizers for dispersing atomized water or lime slurry in the flue gas without wetting the duct surfaces
- Evaluate the effects of varying lime slurry concentrations and injection rates on SO_2 removal from the flue gas
- Check the performance of the downstream electrostatic precipitator and upgrade it if necessary
- Develop an automatic control system for continuous operation

To verify the industrial viability of the system, continuous operations will be carried out using the best performance conditions developed during parametric testing.

3.2 ATOMIZING AIR COMPRESSORS

The atomizing air compressor equipment list is shown in Table 3-4. The atomizing air compressor drawing list is shown in Table 3-5.

The utility requirements to supply the needs of the atomizing air compressors are 90 gpm of cooling water at 35°C maximum inlet temperature. The power requirements are 4,160 V, 60 Hz, 3-phase, at 68.1A, with a power factor of 1.15.

There are no chemical requirements.

Each atomizing air compressor will have its own control and monitoring panel and will be equipped with automatic shutdown functions.

The atomizing air receiver must be manually drained every day and is equipped with an automatic pressure relief valve.

No adverse environmental impacts resulting from the operation of an Atlas-Copco air compressor will occur. The cooling water used will be a side stream of Unit 5 cooling water. The backup cooling water will be isolated through the backflow preventer, and the discharge air will contain no oils or other contaminants.

Table 3-4
ATOMIZING AIR COMPRESSOR EQUIPMENT LIST

Equipment Number	Description	Data Sheet 21178-	Purchase Order 21178-
K-101A	Air compressor, Atlas-Copco, ZR-5, 500 hp, 125 psig, 2,000 cfm, two-stage, rotary-screw		M-100
K-101B	Air compressor, Atlas-Copco, ZR-5, 500 hp, 125 psig, 2,000 cfm, two-stage, rotary-screw		M-100
TI-01	Temperature indicator, air to first-stage atomizing header, 200°F, Ashcroft Model 45-1009-AL-04L	J-10	J-100
PI-12	Pressure indicator, atomizing air receiver, glycerin-filled, 0-160 psig, Ashcroft Model 45-1009-AL-04L	J-03	J-100
PI-01A	Pressure indicator, atomizing air pressure, glycerin-filled 0-160 psig Ashcroft Model 25-1009-AWL-C28	J-04	J-100
T-105	Air receiver, 5'-6" dia. x 18'-0" long, Hanson Manufacturing Co., Los Angeles		M-100
V-530 V-531 V-534	Ball valve, 4 in. steel body, 150 lb flange, full-ported		
V-544 V-545	Check valve, swing type, 4 in. steel body, brass trim, 150 lb flanges		
V-501 V-502 V-503 V-518	Gate valve, steel body, 4 in. 150 lb flanges		
V-504 V-505 V-506 V-507	Gate valve steel body, 2-1/2 in. 150 lb flanges		
V-508 V-509 V-510 V-514 V-516 V-532	Ball valve, 12 in. NPT, brass body, SS ball, full-ported		
V-533	Ball valve, 1 in., brass body, SS ball, full-ported		
V-552	Pressure relief valve, Kunkle Mfg., spring type, 150 lb setpoint, 4 in. inlet flange		

Table 3-5
ATOMIZING AIR COMPRESSOR DRAWING LIST

Dwg. No. SK-	Size	Drawing Title
110	E	Plan @ El. 1077'-0"
120	E	Plan @ El. 1092'-0"
121	E	Partial Plan @ El. 1092'-0"
122	E	Air Receiver Support Steel
130	E	Plan @ El. 1112'-0"
131	E	Piping Floor Covers
132	E	High-Pressure Piping
210	E	E-W Sect. Looking from "B"
211	E	Partial Sect. Looking from "B"
220	E	N-S Sect. at Col. Row 37
320	E	Electric Routing
321	B	Electrical Layout, Switchgear Building
350	B	Block Interconnect Diagram
370	A	Circuit Schedule
380	B	Air Compressor Ammeter Modification
500	E	Piping and Instrumentation Diagram
811	E	Compressor and Duct Requirements
812	E	Inlet duct details
813	E	Inlet Duct Details
814	E	Floor Area Allocation
816	E	Lifting Sling
820	E	Air Receiver Requirements
821	E	Air Receiver Installation

Table 3-5 (Cont'd)

Dwg. No. SK-	Size	Drawing Title
1310735667	D	General Arrangement
1310737101	D	Instrument Cubicle Assembly
1310737885	D	Flow Diagram
1311000595	D	Control Schematic ZR
1311000748	D	Control Face Layout
1311001245	D	Equipment Orientation

3.3 LIME SLURRY PREPARATION AREA

3.3.1 General

The lime slurry preparation area equipment list is shown in Table 3-6. The lime slurry preparation area drawing list is shown in Table 3-7. A simplified overall flow diagram of the system, including this area, is presented in Figure 3-1. (In the figure, all major areas, except the lime preparation area, are shown cross-hatched to make the latter stand out.)

The utility requirements for the lime slurry preparation area are as follows:

- Water (to match the preparation rate) ≤ 60 gpm
- Lime silo – 10 hp
- Agitator – 15 hp
- Lime slurry sump pump – 30 hp
- Instrumentation – 20 A circuit
- Control air – minimal

For the required 60 gpm of lime slurry, the amount of lime required is 1.5 tph.

3.3.2 Lime Slurry Preparation

The proposed lime slurry preparation system consists of:

- A lime silo of 50-ton capacity, for receiving and storing lime hydrate, with a vent baghouse filter
- A rotary air lock valve driven by a variable-speed motor and a screw conveyor for transferring the lime hydrate from the lime silo to the sump
- A lime hydrate slurrying sump of 5,000-gallon capacity with an agitator
- Two sump pumps, one working and one spare, for transferring the lime slurry to the CZD feed system and to the power plant water treatment plant

3.3.3 Receiving and Storing Lime Hydrate

The existing lime silo has enough capacity for 1 day of lime usage. Consequently, daily deliveries of lime will be necessary. This silo was upgraded for use in the CZD system. Its vent baghouse filter was fitted with new bags and its high- and low-level probes provided with low- and high-level alarms. The silos rotary air discharge valve was equipped with a variable-speed motor for controlling the discharge on the hydrate to the lime slurrying sump. The speed of this rotary valve will be controlled by the sump slurry density controller.

3.3.4 Slurrying of Lime Hydrate in the Lime Sump

The lime slurrying system is designed for a fully automatic operation to be governed by the level controller in the lime feed tank.

One of the two sump pumps is designed to operate continuously, pumping the lime slurry to the water treatment plant (there will be little demand for this) and to the CZD lime feed system (there will be a great deal of demand for this). A portion of the total lime pumped by the sump pump will be bypassed back to the sump through the back pressure controller. The slurry level in the lime feed tank will govern the demand for transfer of the lime slurry from the sump to the lime feed tank. The tank level controller will tend to maintain a nearly constant level in this tank by operating lime flow control valve LV25 in the lime transfer line from the sump to the vibrating screen. As the transfer of the lime slurry varies, the lime sump's lime slurry level will also vary.

The lime sump is provided with a level controller, which is designed to maintain a constant level of slurry in the sump by controlling the sump's water inflow.

The lime sump pump feed line is equipped with a sump content density controller to maintain a constant concentration of lime slurry in the sump by controlling the discharge rate of lime hydrate from the silo (speed of rotation of the air lock discharge valve). A flow will be maintained through the lime slurry density gauge, then the ready/standby valve bypass, back to the sump.

The lime hydrates will tend to arch in the silo's discharge hopper. This tendency can be successfully counteracted by aerating the hopper. The lime silo is equipped with air slides and an aeration air compressor for this purpose. The hopper must be aerated constantly during lime withdrawal.

The lime hydrates also tend to cake in a screw conveyor exposed to humid air. To prevent or reduce lime caking in the screw conveyor, the unit is provided with an instrument air purge.

Remote monitoring and control from the control room of equipment in the lime preparation area includes:

- Lime silo high- or low-level alarm
- Lime silo baghouse blower (ON or OFF)
- Screw conveyor (ON or OFF)
- Current draw for the variable-speed drive for the lime silo star valve
- Lime slurry sump level and level setpoint
- Lime slurry density and density setpoint

3.3.5 Lime Storage and Handling

The lime silo has 1 day of storage capacity and will require daily refilling during continuous plant operation. Operators must pay attention to its high- and low-level alarms. Overfilling or complete emptying of the silo must be avoided. When a low-level alarm is activated, the operator must either arrange to have the silo refilled or reduce the lime injection rate if delivery of lime will be delayed. Overfilling the silo is to be avoided since it could cause atmospheric discharge of lime through the silo's pressure relief hatch.

Lime contains impurities in the form of grits (sand) and trash materials that it acquires in its transit from the manufacturer to the power plant. A vibrating screen will remove these impurities from the freshly prepared lime slurry. Screening the lime slurry will help prevent plugging of the atomizers. The impurities will drop from the screen into a collecting trough and be sluiced into one of two grits tanks. Under normal operating conditions, the amount of impurities removed by the screen is expected to be negligible and the operating grits tank will collect mostly sluicing water. This water can be allowed to overflow from the grits tank to the local intake of the fly ash sewer.

3.3.6 Ready/Standby Operation

The CZD system is designed to inject either atomized lime slurry or water into the flue gas. Whenever problems are encountered with lime injection, the operator can revert to operation on water in the standby mode.

The switchover from normal (ready) to standby operation will be done by flipping a hand switch in the control room. When actuated, this hand switch will (1) stop the injection of lime by diverting the flow of lime back to the feed tank and (2) start the flow of process water to the atomizing nozzles to flush them and to continue to cool and humidify the flue gas to prevent opacity excursions. During standby operation, the lime feed pump will continue to operate, recycling all its flow to the feed tank. The sump pump will also continue to operate, but there will be no transfer of lime from the sump to the feed tank and the transfer line will be automatically flushed with water and left full of water. The feed of lime and water to the lime sump will cease automatically on a signal from the sump density and level controllers.

When all problems encountered during lime injection have been resolved, normal plant operation can be resumed by activating the same hand switch in the control room.

The reasons for switching from lime to water injection include:

- High stack opacity
- Low C section temperature
- Lime feed pump failure
- Lime transfer pump failure
- Lime slurry preparation problems
- Instrument control failures
- Shortage of lime
- Vibrating screen failure

Most of the above problems will require equipment inspection and possibly some maintenance work before normal plant operation is resumed.

3.3.7 System Shutdown

The CZD system will operate on Boiler 15 flue gas. Hence, whenever the boiler is down, the CZD system must also be shut down. System shutdown will involve stopping the lime slurry feed pump, stopping the flow of lime slurry from the sump to the feed tank, and flushing all idle lime slurry lines with water and leaving them full of water.

All agitators and one of the lime slurry sump pumps must be left working. The operation of the sump pump will be necessary to provide lime for water treatment.

The idled lime feed pump should be left pressurized with seal water if it is not disconnected from the feed tank and feed header. In this case, the suction and discharge valves should be closed.

During winter operation, care should be taken not to turn off the heat-tracing of lines, feed pumps, and other equipment subject to freezing.

Table 3-6
LIME SLURRY PREPARATION AREA EQUIPMENT LIST

Equipment Number	Description	Data Sheet 21178-	Purchase Order 21178-
DX-01 DE-01 DIT-01	Density gauge/transmitter, lime slurry transfer line		
LE-23 LT-23	Lime pit level indicator	J-32	J-106
LE-02	Lime pit high-high level indicator		
LCV-23	Process water control valve, makeup water to lime slurry pit, Fisher Model 546, 150 psig, globe 2-1/2 in. body / 1 in. port with diaphragm actuator	J-08	J-100
PI-01	Pressure indicator, atomizing air pressure, glycerin-filled, 0-160 psi, Ashcroft Model 45-1279ASL-04L with 50-101SB-04T-CG glycerin-filled diaphragm actuator	J-04	J-100
PI-20	Pressure indicator, atomizing air pressure, glycerin-filled, 0-160 psi, Ashcroft Model 45-1279ASL-04L with 50-101SB-04T-CG glycerin-filled diaphragm actuator	J-04	J-100
P-103A	Lime slurry sump pump, centrifugal, Lawrence Pump Co., 50 hp		
P-103B	Lime slurry sump pump, centrifugal, Lawrence Pump Co., 50 hp		
Y-1	Agitator, Ptero model, 5 hp, 68 rpm, 1,800 rpm 3-phase, 60 Hz, 230/460 V	Existing	Existing
T-1	Hydrated lime storage silo, Sprout-Waldron Co., 15 ft dia., 3,000 cu ft, 60° sloping hopper, 50-ton capacity	Existing	Existing
T-1A	Bin vent filter-flex kleen Model No. A58BV-16. This unit is existing	Existing	Existing
PIC-20	Pressure indicating controller		
HCV-10A	Ready-standby valve, 4-way plug valve with Bettis 5,000 SR 4 actuator with Westlock Accutrack 2004 position indicator and NEMA4 solenoid Xomox Model 047-WCB-316TEF		

Table 3-6 (Cont'd)

Equipment Number	Description	Data Sheet 21178-	Purchase Order 21178-
HCV-10B	Ready-standby valve, 2-way plug valve with Bettis 5,000 SR 4 actuator with Westlock Accutrack 2004 position indicator and NEMA4 solenoid Xomox Model 067-WCB-316TEF		
Y-3	Existing star valve	Existing	Existing
M-1	2/1 chain reduction and a gear reducer with a variable-speed dc drive motor		
M-2	Screw conveyor drive motor, existing	Existing	Existing
Y-2	Screw conveyor, existing, 1'-8" wide x 10'-6" long	Existing	Existing
PV-20	Pressure control valve, ready/standby recirculation, Monyo pinch valve, 2 in. 150 lb flanged		
V-1A V-1B V-1C	Gate valve, NPT mounting, brass body, 150 lb service		
V-3 V-4 V-50 V-51	Plug valve, 150 lb service, 2 in. 150 lb flanges, steel body, SS plug		
V-2 V-5	Ball valve, 1 in. NPT ports, brass body, SS ball		
V-6	Plug valve, 150 lb service, 2-1/2 in. 150 lb flanges, SS body, SS plug		

Table 3-7
LIME SLURRY PREPARATION AREA DRAWING LIST

Dwg. No. SK-	Size	Drawing Title
M-01	D	Lime Slurry Preparation – Piping and Instrumentation Diagram
M-02	D	Lime Slurry Feed – Piping and Instrumentation Diagram
M-03	D	Lime Injection System – Piping and Instrumentation Diagram
M-04	D	Exhaust Duct – Piping and Instrumentation Diagram

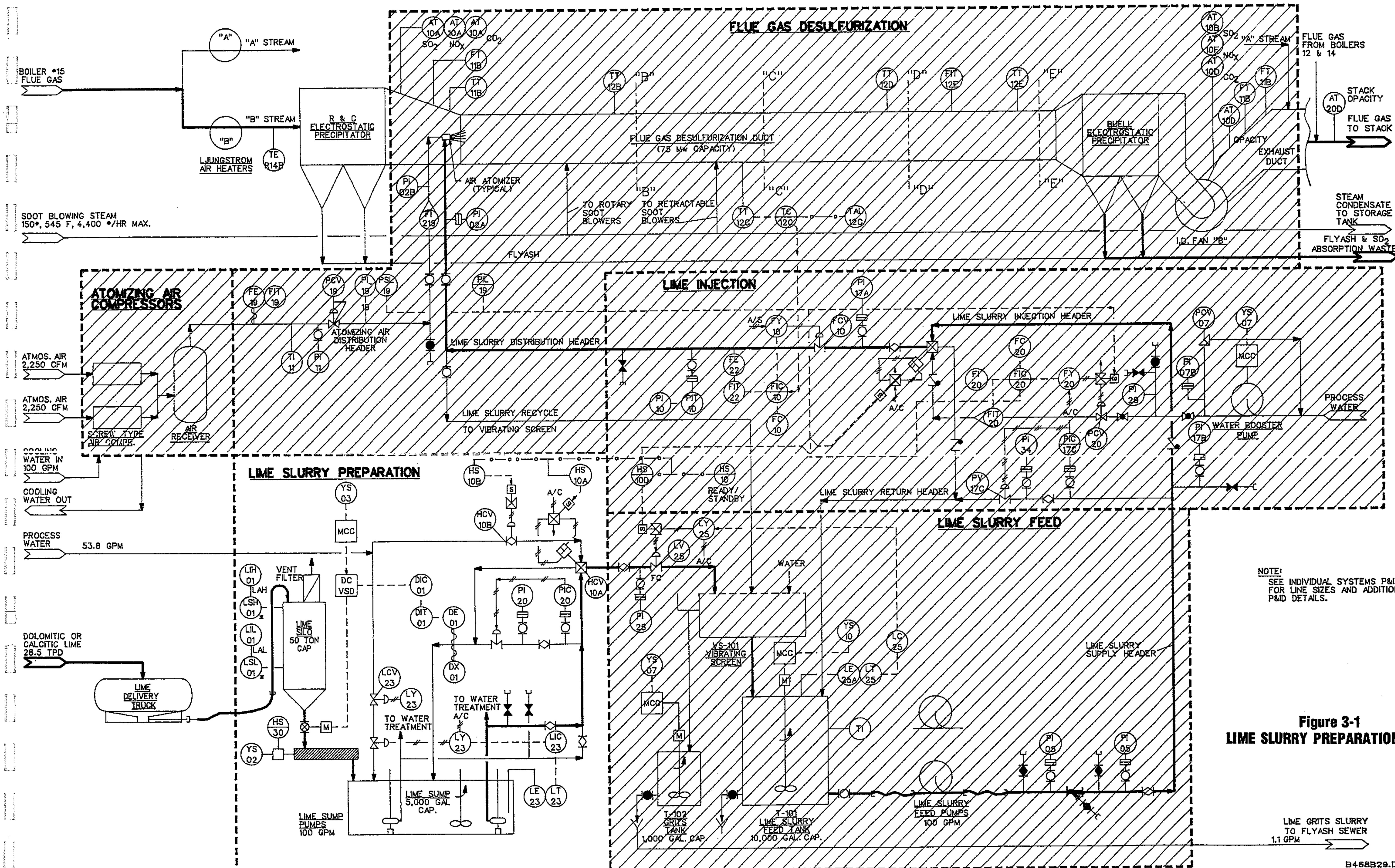


Figure 3-1
LIME SLURRY PREPARATION AREA

3.4 LIME SLURRY FEED AREA

3.4.1 General

The lime slurry feed area equipment list is presented in Table 3-8. A simplified overall flow diagram showing the lime slurry feed area is presented in Figure 3-2. (In the figure, all major areas, except the lime preparation area, are shown cross-hatched to make the latter stand out.)

The utility requirements are as follows:

■ Water (intermittent)	60 gpm, max.
■ Air	Control only
■ Lime slurry feed pump	100 hp
■ Lime slurry agitator	5 hp
■ Grits agitator	3 hp
■ Water booster pump	15 hp
■ Grits washing screen	5 hp
■ Lighting	2 kW
■ Winterization	10 kW

There are no chemical requirements beyond the supplying of lime slurry to the lime slurry feed system from the lime slurry preparation area.

The control circuit for this area is a level controller that throttles the valve in the lime slurry transfer line where it feeds the vibrating screen. Information regarding the tank level is transmitted to the control room.

3.4.2 Lime Slurry Feed

The proposed lime slurry feed system consist of:

- One vibrating screen for the removal of foreign materials from the lime slurry
- Two grits slurry tanks, one working and one spare, both provided with agitators
- Two lime slurry feed tanks, one working and one spare, both provided with agitators, level controllers, and temperature indicators
- Two lime slurry feed pumps, one working and one spare

The system is designed for batch as well as continuous plant operation; hence, it has double tankage.

The vibrating screen is designed to degrit the lime slurry, but will also be used for the removal of foreign matter from this slurry (sand, trash, etc.). Foreign materials will drop from the vibrating screen into the collecting gutter, from which they will be sluiced with water into the grits tank. The grits tank will be periodically emptied into the local fly ash sewer, which will then be flushed with water to prevent it from plugging.

The slurry level in the tank will be controlled by the tank level controller, which throttles the flow of lime slurry from the lime slurry sump pump to the vibrating screen.

The lime slurry feed pump will be used to pump the lime from the feed tank to the lime slurry injection header. There are two pumps. One of them will be connected to the feed tank and lime feed header using hoses. When the operating pump needs servicing, it must be turned off, isolated, drained, flushed, and disconnected from the tank feed header, and the spare pump must be connected to the system using the hoses moved from the other pump. The change of pumps will cause a minimal interruption of the lime injection operation and will require action only by the plant's roving operator.

The two lime slurry feed pumps are of the horizontal centrifugal type. They operate at 3,500 rpm and are equipped with expellers to minimize pump seal wear. The pumps require about 0.2-0.4 gpm of seal flushing water. The use of the seal water is controlled by the seal water flow controllers. The pump seal water harnesses are equipped with isolating valves, check valves, strainers, pressure gauges, and glass flow meters. The details of the seal water harnesses are shown in the lime slurry feed system P&ID M-02.

It is an inherent characteristic of all centrifugal pumps in the CZD system that they are required to operate with relatively small net flows and very high heads. However, for stability of operation, these pumps must pump more than is required by the process. Consequently, the pump discharge piping is designed to return some or all of the pumped fluids to the feed tank to accommodate the pump minimum flow requirement. For example, the sump pumps will have to operate all the time, even when the CZD system is down, supplying a small quantity of lime slurry to the water treatment plant. The pumps have large bypasses to ensure the stability of their operation, and these bypasses must always be in service. The water booster pump is also provided with such a bypass. In the case of the lime slurry feed pumps, the lime slurry feed to the atomizers is taken from a slurry recirculating loop header, with its return discharging to the feed tank. The slurry feed pumps should never be operated without recirculation to the feed tank.

Table 3-8
LIME SLURRY FEED AREA EQUIPMENT LIST

Equipment Number	Description	Data Sheet 21178-	Purchase Order 21178-
T-103	Grits washing tank, 7'-6" dia. x 7'-6" high, carbon steel	(a)	(a)
T-104	Grits washing tank, 7'-6" dia. x 7'-6" high, carbon steel	(a)	(a)
Y-103	Grits washing tank agitator, Chemineer, 1-1/2 hp	DS-104 (a)	M-003 (a)
Y-104	Grits washing tank agitator, Chemineer, 1-1/2 hp	DS-104 (a)	M-003 (a)
VS-101	Vibrating screen, 48 in. dia., 316SS, 3 bhp	(a)	(a)
T101	Degritted lime storage feed tank, 12 ft dia. x 12 in. high, carbon steel	(a)	(a)
T-102	Degritted lime storage feed tank, 12 ft dia. x 12 ft high, carbon steel	(a)	(a)
Y-101	Degritted lime storage feed tank agitator, Chemineer, 37 rpm, 5 bhp	DS-103 (a)	M-003 (a)
Y-102	Degritted lime storage feed tank agitator, Chemineer, 37 rpm, 5 bhp	DS-103 (a)	M-003 (a)
PI-05	Pressure indicator, lime transfer pump recirculation line glycerin-filled, 0-300 psig, Ashcroft Model 45-1009-AL-04L, diaphragm seal 1/2-100-22-04T	J-02	J-100
PI-28	Pressure indicator, lime transfer pump recirculation line glycerin-filled, 0-300 psig, Ashcroft Model 45-1009-AL-04L, diaphragm seal 1/2-100-22-04T		
PI-17A	Pressure indicator, lime feed, Fisher Model 4195 BE, 0-160 psig, 316 SS	J-11	J-100
TI-25A TI-25B	Temperature indicator, Ashcroft 50-E1-60E, lime slurry feed tank	J-10	J-100
PI-25	Pressure indicator, atomizing air receiver, 0-200 psig, glycerin-filled, Ashcroft Model 45-1009-AL-04L	J-03	J-100
P-102A	Lime slurry feed pump, Lawrence, centrifugal, 100 hp		
P-102B	Lime slurry feed pump, Lawrence, centrifugal, 100 hp		
FCV-102A FCV-102B	Flow control valve, Kates Model DB-111T-DM, lime slurry feed pump, expeller feed water		

Table 3-8 (Cont'd)

Equipment Number	Description	Data Sheet 21178-	Purchase Order 21178-
V-32 V-33	Check valve, ball type, 1/2 NPT ports, steel body, SS check ball		
V-34 V-35 V-18 V-22 V-12	Ball valve, 1/2 NPT ports, brass body, SS ball		
V-7	Plug valve, 150 lb body, 2 in. 150 lb flanges, steel body and plug		
V-20 V-13 V-28 V-21 V-14 V-24 V-16 V-17 V-25 V-23 V-19 V-26 V-27	Plug valve, 1 in. NPT mounting, steel body and plug		
LE-25A LE-25B	Level probe, lime slurry feed tank, Drexelbrook		
LT-25A LT-25B	Level probe, lime slurry feed tank, Drexelbrook		
LC-25	Level controller, lime slurry feed tanks		
HS-25	Hand switch, level controller, Allen-Bradley with logic reed block 800T-H2A switch with 800T-XA2R and 800T-XA4R contact blocks		
V-10 V-11	Gate valve, 1-1/2 in. socket weld, steel body, 150 lb service		
LV-25 PCV-25 SV-25 LY-25	Control valve, Robins and Meyers RKL pinch valve, 2-1/2 in. 150 lb flange mounting		
V-8	Gate valve, 1 in. body, socket weld, steel body		

Table 3-8 (Cont'd)

Equipment Number	Description	Data Sheet 21178-	Purchase Order 21178-
V-9	Gate valve, 1/2 in. body, socket weld, steel body		
V-29 V-30 V-31	Ball valve, 1/2 in. NPT mounting, brass body, SS ball		

(a) This equipment was available at Seward Station from previous CZD test programs.

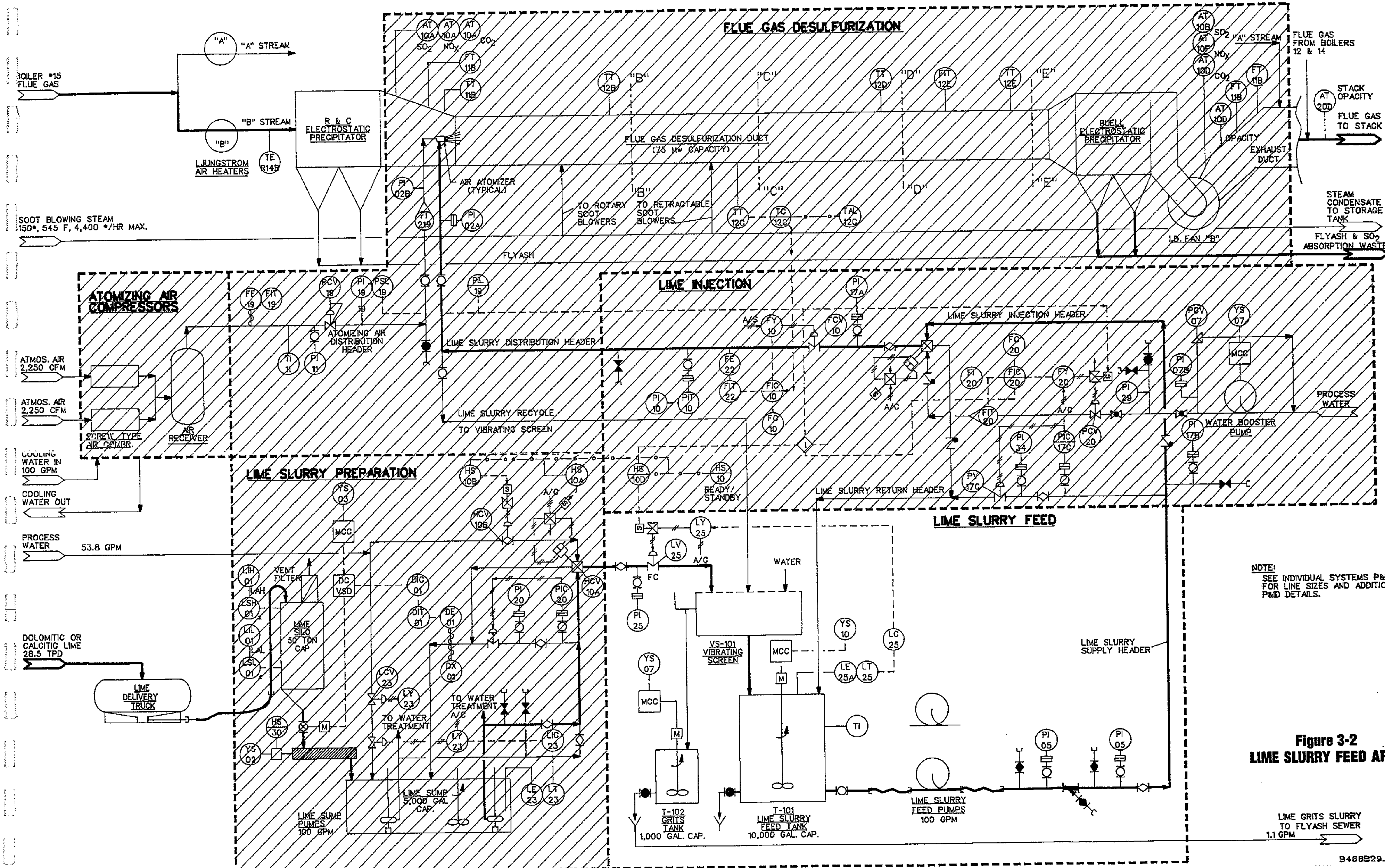


Figure 3-2
LIME SLURRY FEED AREA

3.5 LIME SLURRY INJECTION AREA

3.5.1 General

The lime slurry injection area equipment list is shown in Table 3-9. Details of the lime slurry injection atomizer array system are considered proprietary information and are not shown or discussed. The lime slurry injection area drawing list is shown in Table 3-10. A simplified overall flow diagram showing this area is presented in Figure 3-3. (In the figure, all major areas, except the lime slurry injection area, are shown cross-hatched to make the latter stand out.)

The utility requirements for the lime slurry injection area are as follows:

■ Winterization	4 kW
■ Lighting	2 kW
■ Instrument power	3 kW
■ Instrument air	Minimal

There are no requirements for chemical addition on an operational basis. Control and monitoring are covered in Section 3.8.

3.5.2 Preinjection Operations

Before anything is injected into the duct, one of the two atomizing air compressors must be started up and the compressed air supply piping and distribution header must be drained free of water. The compressed air will not be dry, and water is likely to collect in the air receiver, which must be drained daily.

It is advisable that this atomizing air compressor be run for an hour or so before starting the injection of water into the duct. Compressor operation should be checked by the roving operator before starting atomization. Checking must include the air intake filter; cooling water flow; air discharge pressure and temperature; compressor oil; and air receiver pressure, temperature, and water content. Before water is injected, atomizing air must be admitted to the atomizing nozzles to cool them.

The injection of lime must always be preceded by the injection of water in order to:

- Cool the flue gas system to its CZD operating temperature
- Check the operation of atomizers
- Check the flue gas temperatures

Water injection must be reduced if any temperature in the C section is below 150°F, and all problems must be resolved before switching to lime injection.

3.5.3 Description of the Injection Process

The proposed lime slurry injection system consists of:

- Lime slurry and water piping
- Flow controls on the top of the duct (other than the lime slurry distribution header and atomizer feeders)
- A water booster pump and associated water piping at ground level

Lime slurry will be supplied to the injection lime header from the lime feed system via the loop main, which consists of the feed supply and the excess feed return headers. The operation of atomizers will require relatively high constant lime slurry injection pressure, which will be maintained at a constant level at the inlet to the injection header by the back pressure controller in the lime slurry return header. The flow of lime slurry or water to the atomizers' distribution header will be controlled by the flow controller, which will be controlled by the C section temperature controller.

The lime slurry injection header is connected to the lime slurry feed loop via a four-way valve, which also connects the lime injection header to the water supply piping from the water booster pump. The use of the four-way valve permits the lime injection header to be flushed with water whenever the lime injection is interrupted. The lime and water flow control valve is connected to the low-pressure switch on the atomizing air supply header so that the valve will shut in case of low atomizing air pressure.

This arrangement protects the flue gas handling system from being flooded with unatomized lime slurry or water. Such a flooding could require a boiler shutdown before it could be cleared.

The power plant domestic water distribution system will provide water for flushing the atomizers and their lime slurry supply piping and for injection of water into the flue gas stream. The domestic water system pressure varies, making it inadequate for high flow rate operation of the atomizers. Consequently, the CZD injection system is equipped with a water booster pump to maintain an adequate water supply pressure for the operation of atomizers during high-flow-rate water injection periods, when the water is used for cooling the flue gas treating system prior to the injection of lime, and for flushing the lime slurry piping and atomizers at the end of the lime injection period. The water booster pump must operate continuously to make water available for emergency use at all times.

The water booster pump has a pump bypass with a pressure controller for controlling the pump discharge pressure. A bleed line keeps the pump cool when it is operating without a net discharge of water.

Table 3-9
LIME INJECTION AREA EQUIPMENT LIST

Equipment Number	Description	Data Sheet 21178-	Purchase Order 21178-
PI-17A PI-17B PI-29 PI-34 PI-11 PI-19	Pressure indicator, glycerin-filled, 0-200 psi, Ashcroft Model 45-1009-AL-04L, diaphragm seal 1/2-100-22-04T	J-02	J-100
FIT-20	Flow indicating transmitter, 0-150 gpm, 150 psig body, 4-20 mA, 2 in. flanges, steel body	J-17	J-102
PIT-20	Pressure indicating transmitter, lime slurry distribution header pressure, Fisher Model 1151GP, 0-160 psig range, diaphragm type	J-12	J-100
TI-01	Temperature indicator, air-to-first-stage atomizing header, Ashcroft 50-E1-60E	J-10	J-100
FT-11A FT-11B	Kurz multipoint probe		
FIT-19 FE-19	Mass flow indicating transmitter, atomizing air line, 125 psig, 4,000 scfm, 4-20 mA, Kurz	J-31	J-105
PCV-19	Pressure control valve, atomizing air supply, Fisher Model 399-161, 100-125 psig operating range, 6X4-300 LB body, carbon steel body	J-06	J-100
PI-01A	Pressure indicator, atomizing air pressure, glycerin-filled Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21A	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	DS-103	M-003
PI-02A	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01B	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21B	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-19	J-109
PI-02B	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100

Table 3-9 (Cont'd)

Equipment Number	Description	Data Sheet 21178-	Purchase Order 21178-
PI-01C	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21C	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-19	J-109
PI-02C	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01D	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21D	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-19	J-109
PI-02D	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01E	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21E	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-19	J-109
PI-02E	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01F	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21F	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-20	J-109
PI-02F	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01G	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21G	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-20	J-109
PI-02G	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100

Table 3-9 (Cont'd)

Equipment Number	Description	Data Sheet 21178-	Purchase Order 21178-
PI-01H	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21H	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-20	J-109
PI-02H	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01I	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21I	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-20	J-109
PI-02I	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01J	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21J	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-20	J-109
PI-02J	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01K	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21K	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-21	J-109
PI-02K	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01L	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21L	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-21	J-109
PI-02L	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100

Table 3-9 (Cont'd)

Equipment Number	Description	Data Sheet 21178-	Purchase Order 21178-
PI-01M	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21M	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-21	J-109
PI-02M	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01N	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21N	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-21	J-109
PI-02N	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01P	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21P	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-21	J-109
PI-02P	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01Q	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21Q	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-21	J-109
PI-02Q	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PI-01R	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21R	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-21	J-109
PI-02R	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100

Table 3-9 (Cont'd)

Equipment Number	Description	Data Sheet 21178-	Purchase Order 21178-
PI-01S	Pressure indicator, atomizing air pressure, glycerin-filled, Ashcroft Model 25-1009-AWL-C2B	J-04	J-100
FI-21S	Flow indicator, atomizing air to nozzle, Ketema-type 20-1340-B10S, 200 scfm	J-21	J-109
PI-02S	Pressure indicator, lime injection pressure, glycerin-filled, Ashcroft Model 25-1009-AL-02L with diaphragm seal model number 1/2-100SS-02T	J-04	J-100
PSL-19	Pressure set limit switch – set at 60 psi		
FE-22 FIT-22	Flow element, flow indicating transmitter, lime slurry service, altoflux "K" series		
PIC-17C	Pressure indicating controller, Fisher controls Model 4195K		
PV-17C	Pressure control valve, Robbins and Meyers RKL pinch valve with positioner, 1-1/2 in., 150 lb flange mount with 1 in. port		
HCV-10D	Ready/standby valve, 4-way plug valve with Bettis 5,000 SR4 actuator with Westlock Accutrack 2,004 position indicator and NEMA4 solenoid Xomox Model 047-WCB-316TEF		
FCV-10	Pressure control valve, Robbins and Meyers RKL pinch valve with positioner, 2-1/2 in., 150 lb flange mount		
FCV-20	Pressure control valve, Fisher control valve with positioner, 1-1/2 in., 150 lb flange mount with 1 in. port		
P-104	Water booster pump, Gould, centrifugal		
FE-12 FIT-12	Kurz multipoint probe purchased in 1987 rebuilt at the factory and calibrated in 1992		
V-47	6 in. gate valve, 300 lb steel body, 300 lb flange mount		
V-46	2 in. globe valve, 300 lb flange mounted steel body		
V-44	Ball valve, 1 in. NPT mounting, brass body, SS ball		
V-45 V-49 V-51 V-53	Ball valve, 1/2 in. NPT mounting, brass body, SS ball		
V-43 V-48	3 in. globe valve, butt-welded, 300 lb steel body		

Table 3-9 (Cont'd)

Equipment Number	Description	Data Sheet 21178-	Purchase Order 21178-
V-42	2 in. gate valve, 150 lb flange mount steel body		
V-50	1/2 in. gate valve, NPT mounting, brass body		
V-41	2 in. flange-mounted ball check valve, glass-impregnated ball check, Xomox		
V-52	1 in. flange-mounted ball check valve, glass-impregnated ball check, Xomox		
V-36	3 in. flange-mounted ball check valve, glass-impregnated ball check, Xomox		
V-40	1-1/2 in. flange-mounted ball check valve, glass-impregnated ball check, Xomox		
V-37	1-1/2 in. flange-mounted plug valve, steel body		
V-38	2-1/2 in. flange-mounted plug valve, steel body		

Table 3-10
LIME INJECTION AREA DRAWING LIST

Dwg. No. SK-	Size	Drawing Title
M-01	D	Lime Slurry Preparation – Piping and Instrumentation Diagram
M-02	D	Lime Slurry Feed – Piping and Instrumentation Diagram
M-03	D	Lime Injection System – Piping and Instrumentation Diagram
M-04	D	Exhaust Duct – Piping and Instrumentation Diagram
1901	D	Atomizing Air Header Isometric [a]
1902	B	Lime Slurry Supply Header Isometric [a]
1903	B	Crossover Atomizing Air Supply Isometric [a]
1904	B	Lime Slurry Feed and Supply Isometric [a]
1905	B	Miscellaneous Piping Isometrics [a]

(a) These drawings contain proprietary information and are not included in Appendix C.

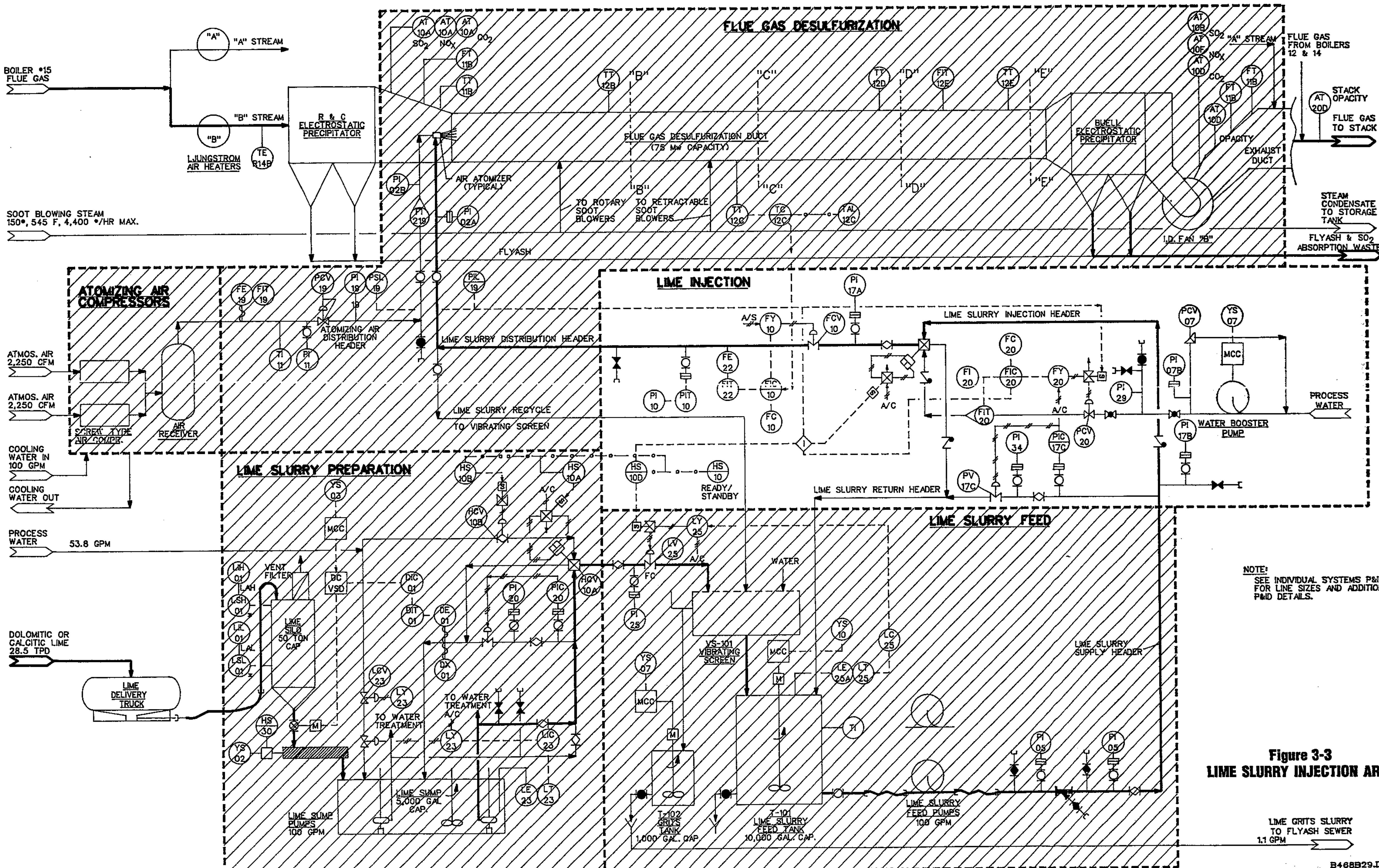


Figure 3-3
LIME SLURRY INJECTION AREA